Plate at p. 126 belongs to vol i

ORGANIC REMAINS

OF A

FORMER WORLD.

FRONTISPIECE.

Published by M.A. Nattali 1833.

ORGANIC REMAINS OF A FORMER WORLD.

AN EXAMINATION OF THE

MINERALIZED REMAINS OF THE VEGETABLES AND ANIMALS

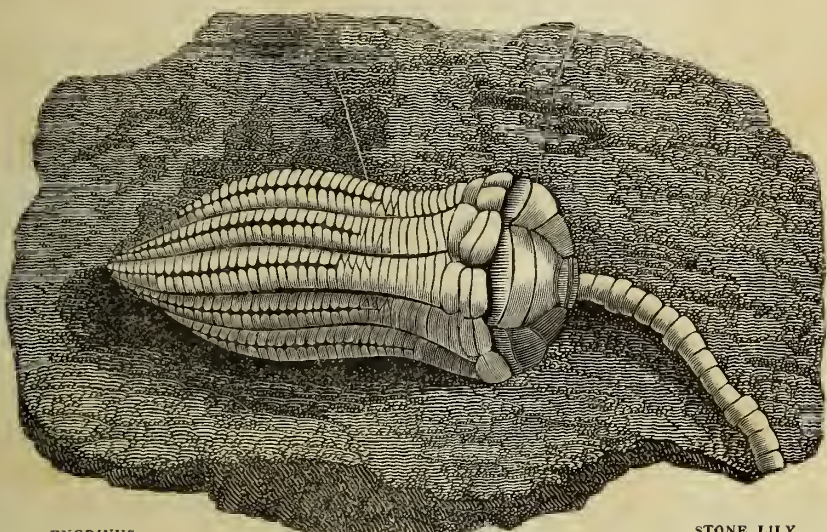
OF THE

ANTEDILUVIAN WORLD;

GENERALLY TERMED EXTRANEOUS FOSSILS.

BY JAMES PARKINSON.

IN THREE VOLUMES.



ENCRINUS. STONE LILY.

THE SECOND VOLUME;

CONTAINING THE FOSSIL ZOOPHYTES.

SECOND EDITION.

LONDON:

M. A. NATTALI, 24, TAVISTOCK-STREET, COVENT-GARDEN.

M.DCCC.XXXIII.

T. Combe, Junior, Gallowtree-gate, Leicester.

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VOL. II.

PREFACE

TO

THE SECOND VOLUME.

As it is incumbent on every author to adapt his labours, as much as possible, to the wishes and expectations of his Readers, so it is also necessary to point out the reasons, which may have induced him to depart from those modes, which would have best accorded with their expectations. Under this consideration, the Author offers the following observations to the purchasers of this volume.

Learning, with regret, that it has been imagined, by many, that the present volume would have concluded this work, he is under the necessity of observing that this opinion could not have been derived from any declaration of the Author, whose advertisements have never specified more than that the first volume would contain the fossils belonging to the vegetable kingdom. Fully aware of the much greater number of interesting subjects which the animal kingdom would present for examination, he never could venture to conjecture to what extent they might enforce him to protract his labours. The opinion,

he believes, has originated from the expressions of some of the periodical publications which have concluded their observations on the former volume, with stating the nature of their expectations respecting *the future volume*, as if no more was intended to be published. It is true that the author has never yet specified of how many volumes the work is to consist; and it is as true that he is unable, even at the present moment, to form a decided opinion on the subject. As his intention is to furnish all the important information he can obtain, respecting the different objects of his examination, the size of the work will necessarily depend on the success with which his inquiries may be pursued: but on this point it is necessary to be still more explicit.

Two modes of prosecuting the work offered themselves for his adoption. The one required only a faithful history of the different opinions of former writers on these subjects. The figures necessary for illustration might, in this case, have been obtained, by copying those which appeared to have been best chosen and best executed, in the respective volumes of these authors. A work executed on this plan would have been acceptable to many, since no such work at present exists in our language. It would also have possessed this advantage, that its size might have been, at the first, easily ascertained and limited.

The other plan would be much more comprehensive. It would comprise so much of the labours of preceding writers, as should serve to furnish a correct history of the progress of knowledge respecting each subject of examination. Their several opinions would be noticed, and their agreement or disagreement with the more accurate knowledge of the nature of these substances, which later observations have furnished, would be also stated. A sedulous examination and careful comparison of different specimens of the same species would be required for this purpose; and, where indisputable inferences could not thus be obtained, such conjectures might be offered as analogy and probability appeared to support. Most of the subjects for the plates, which would accompany a work conducted on this plan, would be necessarily original; by which the general fund of information, respecting these much neglected subjects of admiration, would be increased: a circumstance much to be desired; since, in even the most respectable works which have appeared, the figures have been, too frequently, merely copies from those of former works.

The superior advantages which would thus be produced were so obvious as to lead to the determination of attempting to form a work upon this model. It was not however overlooked, that considerable difficulties

must be expected to impede and interrupt the attempt. The greatest of these appeared to be in the acquisition of a sufficient variety of specimens, to admit of the necessary comparison, and to allow the deficiencies of some, so to be made up by others, as to supply a tolerably correct notion of the figure, and even of the nature of the body which, perhaps, no single specimen could furnish.

From this difficulty proceeded, in a great measure, the inability to determine the size of the intended work. The instruction furnished by the specimen which may be possessed to-day may add very little to the knowledge which we have derived from others; and will therefore demand but little room for its communication. But the specimen which accident or industry may throw in our way to-morrow may furnish that degree of information, which may lead to a true knowledge of the real nature of the substance under inquiry; and, perhaps, to the correction of all previously adopted opinions respecting it. The new facts which would be thus gained, and the various reasonings and conjectures to which they would lead, would necessarily occasion a wide difference between the space which the article would then require, and that which it had, at first, been expected to occupy. A few such fortunate occurrences, would, it is evident, extend the work much beyond the bounds within which it might originally have been proposed to be

confined: and might necessarily occasion an extension of the work beyond those limits within which the author had bound himself to confine it. On this account, it was resolved to leave the size of the work to be determined by the quantity of additional information which might be furnished, by the accession of new materials; taking care, at the same time, to guard against the admission of uninteresting and irrelevant matter.

How far the attempt to form the present volume on these principles, and on this model, has succeeded, the author leaves to the judgment of the candid: assuring them that, in the prosecution of the work, no unwarrantable protraction of it shall be admitted. He is very desirous to complete the work in a third volume; but when he considers the multitude of subjects which must be examined, he finds himself unable to pledge himself to the observance of the limits which would be thus prescribed.

Anxious to obtain, and to communicate, the fullest information on the various subjects of his inquiry, he will be much obliged by any specimens or observations, illustrative of the nature of the different substances which have been, or which remain to be, examined. Any such communications he will with pleasure place before

the public, either embodied in the present work, or in a separate volume of oryctological communications.

It is proper to remark that such only of the engravings of the present volume as are not coloured, have been taken from other works: and that all those which are coloured, have been copied, for this work, from the specimens themselves.

DESCRIPTION OF THE FRONTISPIECE.

THE fossil animal body which is here represented is of the genus *Alcyonium*. Bodies of a similar form and structure are found in various parts, but no where in greater quantities than in the neighbourhood of Touraine, in France, and in Wiltshire. It was at first supposed that this fossil had been obtained from the latter of these places; but on comparison with the Wiltshire alcyonites, it appears that, although of the same original structure with them; yet the changes which it has undergone are such as rather point out its being a French fossil. The original animal fibres are now entirely silicious; and the interstices are filled with carbonate of lime. At its inferior part are the remains of its footstalk; on the surface the fibrous structure appears; and on the left side, and at the superior part, a portion of the original investing or cortical part may be seen.—*Vide* p. 125.

ORGANIC REMAINS

OF A

FORMER WORLD, &c.

LETTER I.

MODE IN WHICH THE WORK IS INTENDED TO BE PURSUED.... REASONS FOR EMPLOYING THE EPISTOLARY FORM.

I VENTURED, my dear friend, to assert, in the series of letters of which the former volume is composed, that the examination of the fossils of the animal kingdom, would yield a much greater degree of interest and amusement, than could be expected from those of the vegetable kingdom. This assertion was made on the consideration, that from the composition and structure of many of the more solid parts of animals: such as the bones, the shelly and crustaceous coverings, horns, scales, &c. many more of their remains would be found in a state of preservation, than could possibly be the case with those of vegetables.

The parts of animals, which have been just particularized, are such as must also necessarily lead to observations, which may be more illustrative of the nature of the individuals to which they belonged,

than the fossil remains of vegetables. In the former, the entire figure of the investiture of the animal is sometimes preserved; and where this is not the case, sufficient is frequently found, to point out the genus, and in many cases, even the species of the animal: but pieces of wood, leaves, with the kernels and coriaceous coverings of fruits, can seldom do more than lead to uncertain conjecture, respecting the natural order or class under which the plant should be placed.

It is my intention, whilst proceeding to inform you of the result of my investigations, to continue to place them before you in an epistolary form. This is indeed rendered necessary, in some degree, by that form having been adopted in the preceding volume. But, independent of that circumstance, it is the form which, for several other reasons, I am disposed to prefer. By adopting this mode, I shall feel myself more at liberty to introduce such matter as, although highly useful in illustration, might hardly perhaps be admissible in a work composed according to the more rigid forms, in which disquisitions of this kind are generally presented to the world. The epistolary stile too appears to be well suited to the discussion of subjects of natural history. It allows that familiar mode of expression, which seems to be best calculated for those illustrations which are required by the various topics, which this study embraces. It also admits of the introduction of those reflections, which although, perhaps, not unacceptable, and which naturally arise from the immediate subject of inquiry, might appear to be too digressive, in a work written in a truly systematic form. But another circumstance, it must be admitted, has had some considerable weight in determining this choice. These observations have been put to paper, at short and uncertain periods, when the fatigue arising from professional labours has left the mind in such a state, as to render it necessary to record the results of its investigations, in that familiar kind of stile as might best suit the writer in such moments; and as might not demand the extreme severity of criticism.

It is, however, not intended to extend too widely the privileges which are thus assumed: nor is it intended unnecessarily to indulge in the discussion of any collateral subjects. Indeed, the freedom with which introductory matter was introduced in the former volume renders the necessity of such an encroachment less imperious in this stage of my labours. In a work like the present, however, which is intended to embrace all that is instructive and interesting in a science, respecting which so little has appeared in this country, it cannot indeed be objectionable to notice, occasionally, the more important observations which have occurred to the zealous and well-informed in other parts of the world; and farther than this it is not intended to wander.

The history of the several animal fossils will be given with all the care and precision which I shall be able to employ. But however correctly their physical, their chemical, and even their geographic characters may be given, little is accomplished, unless as close a comparison be made between the fossil and the recent animal, as circumstances will admit. This, it must be observed, must of necessity lead to such observations on the habits and economy, as well as of the chemical composition of the recent animal, as perhaps at first sight might appear to be unnecessary. It is, however, presumed that this extension of inquiry will not be found in any case to be employed beyond the bounds which fair illustration may demand.

It has been considered as very desirable, not only to ascertain the animals, from which the different fossil animal remains have derived their origin; but also to determine, as nearly as could be, the state in which their remains were intended to exist, in the present state of this globe. Hence, after having taken a slight glance at the original animals, and examined the various changes which they have undergone; I shall endeavour to trace them into that state, in which they appear to possess the highest degree of utility as fossil substances, and in which they have obtained, comparatively, a permanent form. This

state, in by far the greatest part of the substances towards which our inquiries will be directed, will be found to be that of lime-stone, marble, calcareous spar, chalk, &c. When found in this state, and still possessing traces of their original mode of existence, they will be regarded as fit subjects to derive illustration from the labours of the artist.

LETTER II.

ARRANGEMENT OF LINNÆUS....OF WALLERIUS....THAT ADOPTED IN THE PRESENT WORK....ZOOPHYTES CLAIM PRIORITY OF EXAMINATION....CORALS.

THE arrangement which has been adopted in the present volume requires a few words in explanation. Linnæus commences his arrangement of secondary fossils with the mineralised remains of man, passes on to those of mammalia, birds, amphibia, fishes, and insects, and concludes with those of worms; in which are comprised, asteriæ, echini, the inhabitants of shells, and those animals which, from apparently partaking both of an animal and vegetable nature, have been distinguished by the name of *zoophytes.* After having noticed, in this order, the fossil remains of animals, he then proceeds to those of vegetables.

Wallerius, on the other hand, treats first of the vegetable kingdom, and then proceeds to arrange those of the animal kingdom, in the following order; corals, worms, shells, insects, amphibia, fishes, birds, quadrupeds, and, lastly, man. The latter of these arrangements, appearing to be in several respects preferable to the former, it has been here nearly adopted.

Previous to the excellent remarks of Mons. Jussieu, corals were regarded entirely as marine plants; and consequently were considered as belonging to the vegetable kingdom. As their nature became more known, their claims, to be ranked among the subjects of the animal kingdom, were more generally acknowledged; whilst the general forms under which they existed irresistibly led to the conclusion, that these, at least, must depend on the process of vegetation. They were, therefore, frequently regarded as a class of beings, which, deriving their existence from the energies both of vegetable and of animal life, formed the connecting link of the two kingdoms; and hence the situation allotted for them by classification has sometimes been the last genus of animals, and the first of vegetables.

Indeed when, together with their vegetable forms, certain circumstances in their growth are also considered, the passing from the investigation of vegetables, directly to that of these bodies, appears to be the most rational progress of inquiry. The mind is then best enabled, by the inquiry in which it was last engaged, to form the necessary comparison, and to adjudge how little vegetation has been concerned in the production of beings, which appear to possess so many properties in common with plants, as to have forced those who most strongly denied their partaking in the least degree of a vegetable nature, into the necessity, whilst speaking of them, of employing figurative language entirely borrowed from the vegetable kingdom. This consideration alone seems sufficient to direct their being disposed of, nearly in that situation, in which they are placed by Wallerius, and which it is here intended they shall also retain. But another consideration, of still greater force, urges that their fossil remains should be examined previously to those of other animals. The nature of the changes which animal substances undergo, whilst passing into a mineral state, is but little known, and considerable difficulties oppose the attempt to ascertain the modes, by which nature has determined, that this particular change shall be accomplished. The greatest

chance, however, of obtaining some information upon this subject, it must be obvious, will be yielded by making those animal substances the first objects of our inquiry, which were originally the most simple in their constitution. Such, it must be admitted, are corals; the simplicity of the composition of which has been made known to us by the interesting experiments of Mr. Hatchett.

But, although it is intended, for this reason, to adopt the order of Wallerius, so far as to commence the animal fossils with the corals, and then to proceed upwards in the scale of animation, it is not, however, proposed to separate, with this author, these bodies from the class of worms, (*vermes*, Linn.) It is, on the contrary, intended still to consider corals in their fossil state, as forming different genera and species, in the order of *zoophytes*, in the class of *vermes*.

Of the origin of coralloids, as the fossil corals are sometimes termed, it will not be necessary to say much at the present day, when so many proofs have been adduced of their having derived their origin from real corals, which have been disposed in such situations as have conduced to the changes which they have undergone. The more ancient notions of their having proceeded from the operations of a *vis plastica*, *vis formativa*, &c. need no farther notice, than to observe, that even in the last century, Dr. Woodward admitted it to form a part of the hypothesis, by which he proposed to account for the origin of various secondary fossils, and especially of coralloids.

The original hardness of many of the *zoophytes* led to a considerable degree of confusion; since many of the earlier naturalists, not perceiving the actual change which the fossil bodies of this kind had undergone, made no distinction; but considered these bodies as existing in their original natural state. But, as the science advanced, the circumstance of their having been found in subterraneous situations called for explanation; nor would fanciful and unfounded suppositions be admitted. It was no longer sufficient to say, with Encelius, that they were formed by the indurating power of the air; or that they

derived their origin from the viscosity of the earth; nor, with Woodward, that the corals, &c. being brought into a state of solution, at the time of the Deluge, their particles, after some time, uniting and combining into masses, composed the nodules of coral, &c. which are now found deposited in the bowels of the earth.

The existence in subterranean situations of the ramose, and other corals, which bore an exact resemblance to those which were known to be the inhabitants of the ocean, was, however, long attempted to be accounted for, by suppositions approaching no nearer to probability than these. Count Moscardi (Not. Overo Museo de Conte de Lod. Moscardo, p. 187.) and Oligerius Jacobæus (Mus. Reg. p. 3.) were, however, led by the appearance of some of the fossil alcyonia, to suppose that they had actually undergone a change, and were real petrifactions. But they still were totally ignorant of the real origin of these substances; and, misled by their forms, they believed them to be different species of terrestrial fungi.

The learned Buttner, in the year 1714, removed every doubt respecting the origin of these bodies, and rendered it manifest, that all fossil corals had primarily been the inhabitants of the ocean. This opinion was opposed, indeed, by our countryman Woodward, but with arguments too futile to require notice; it therefore was generally accepted, and the knowledge of the real nature of fossil corals was established.

LETTER III.

REMARKS ON RECENT CORALS....EXPERIMENTS ON, BY MR. HATCHETT.

Some are of opinion, that whilst contemplating the nature, and examining the constituent parts, of those substances which have undergone an almost total change in their composition, it is unnecessary to take into consideration, either the circumstances under which they previously existed, or the principles which entered into their original constitution. Not entertaining this opinion, but considering that many may feel themselves highly interested by marking the progress of the change of organized bodies, into substances possessing the properties of a mineral, greater freedom will be indulged in, whilst selecting the various topics, the discussion of which is to fill the following pages.

To form even a probable conjecture, respecting the nature of the changes, which will be the chief objects of our investigations, it appears that the nature of the substances which have undergone the change must first be known; their constituent principles will therefore be particularized. Since these changes may also be even influenced by the peculiar habits and economy of the living animal, these will also be occasionally adverted to. Thus, in the present instance, the chemical examination of the recent coral, and an inquiry into the properties possessed by the animal which inhabited it, will be likely to yield us considerable aid, whilst determining the changes which have taken place in the fossil coral.

So great is the resemblance which corals bear to vegetables as to have long occasioned, as has been already observed, their being considered

as subjects of the vegetable kingdom. They are in general attached to other substances by a part, analagous, in its form, to a *root;* from which proceeds a *trunk*, ramifying into *branches*, which, at certain times, appear to be beset with *flowerets* and *fruits* of beautiful and fantastic forms. Their real nature was first ascertained by Peysonell, who, in 1727, communicated his observations respecting them to the Royal Academy of Sciences at Paris. This accurate observer, not only shewed that corals yielded, on the application of heat such products as peculiarly belonged to animal substances; but also pointed out several particulars respecting the coral polype, which could not fail of determining, that corals belonged entirely to the animal kingdom. The observations of Jussieu, Reaumur, Donati, and others, confirmed this fact; which, however, was not so generally received, but that several learned men still hesitated in admitting that the forms which corals bear could be derived from the powers of animal life alone. All doubts were, however, removed by the observations of Mr. Ellis, in his essay on the Natural History of Corallines, and of many curious and uncommon Zoophytes.

By the experiments of Mr. Hatchett, instituted for the purpose of ascertaining the component parts, as well as the mode of formation, of different zoophytes, our knowledge respecting these animals has been very considerably increased. He was enabled by these experiments to ascertain, that corals, and the numerous tribe of zoophytes, with which they are connected, differ, in composition, from the varieties of bone and shell, only by the nature and quantity of the hardening principle, and by the state of the substance with which it is mixed or connected. The porcellaneous shells, such as *cypreæ*, &c. were found to be composed of animal gluten and carbonate of lime; and to resemble, in their mode of formation, the enamel of teeth; the earthy matter being blended with the animal gluten. The pearly shells, or those composed of nacre or mother of pearl, such as *patellæ*, &c. he found to be composed of carbonate of lime, and a gelatinous, cartilaginous,

or membranaceous substance; and that they resembled bone, in their hardening matter being secreted and deposited upon the membranaceous substance. It appeared that the gluten, in the porcellaneous shells, existed in so small a degree of natural inspissation, and was so little advanced in organization, that when the carbonate of lime was dissolved, even by very feeble acids, little or no vestige of jelly, membrane, or cartilage could be perceived. In the pearly shells, on the contrary, that substance, which served in the porcellaneous shells merely as a gluten, was not only more abundant, but also more inspissated, becoming visible and palpable. This chain of connexion between bone and shells, Mr. Hatchett found, was also extended between shells and corals. He found an exact similarity between the substances forming the various shells, and that which forms the various madrepores and millepores; the nature of these bodies being so completely the same, that the changes or gradations of the one are to be found in the other. Thus some madrepores and millepores, like the porcellaneous shells, afforded a gelatinous substance, on the removal of the carbonate of lime; whilst others yielded a substance possessing all the characters of the membranaceous substance, contained in the shells formed of nacre or mother of pearl.

Many of the circumstances which the experiments of Mr. Hatchett have made known, throw a considerable degree of light upon the formation of the different animal fossils, and will, therefore, be occasionally referred to in the succeeding pages of this work.

LETTER IV.

CLASSIFICATION.....NOMENCLATURE.....TUBIPORITE.....APPROACHING TO TUBIPORA MUSICA.....TUBIPORA STRUES.....IMBEDDED IN MARBLE......MR. HATCHETT'S EXPERIMENTS......ANIMAL MEMBRANE DETECTED IN THE MARBLE FORMED BY THIS CORAL.

The classification of zoophytes by the illustrious Linnæus, is that which will be adopted in the following pages. Mons. Cuvier, whose indefatigable exertions for promoting the advancement of comparative anatomy and oryctology, demand the gratitude of every lover of science, has proposed a different arrangement of animal bodies; which does not, however, seem necessary to be here adopted in preference to that of Linnæus. Indeed, without dwelling on the admission of holothuria and siphunculus among the zoophytes, the disposal of echinus and asteria among those animals which derive their names from their resembling plants in their figure, appears to render the classification of Cuvier objectionable. By the adoption of the arrangement of Linnæus, that confusion also will be avoided, which might arise from any deviation from that general language of natural historians, which has been derived from that particular mode of classification.

It is also necessary to make a few remarks respecting the vocabulary of oryctology. This science, it must be acknowledged, is too little advanced in this country, to have obtained a full and correct nomenclature. The restricted knowledge we possess, respecting many fossils, is one considerable cause of the little progress which has been made in this respect: added to which, is the circumstance of the English writers on these subjects having generally employed, unchanged, the several terms which have served to designate these substances in the Latin tongue.

The English termination *lite*, which directly proceeds from the Latin termination *lithus*, implying a stony nature, appears to be sufficient, if added to the name of any substance, to point out its having sustained the petrifying change: thus, corallite conveys the idea of a petrified coral. But, in some instances, it will be found that brevity and euphonia will demand a little alteration in this termination, from its not being always capable of easy adaption to the last syllable of the name of the substance, which is intended to be described, as having undergone this particular change. In these cases, both in the Latin tongue and the French language, the termination *ite* has been employed to denote that the substance spoken of has undergone the process of lapidification. By the employment, therefore, of one or of the other of these terminations, I hope to be almost always capable of clearly designating the petrified substance, with the least possible change of received terms.

Proceeding, therefore, to the consideration of the zoophytes, we shall, agreeably to the proposed arrangement, take for the first subject of our examination, the genus tubipore; *(tubipora*, Linn.) being the first of the order of zoophytes in the Linnæan classification.

Tubiporites is the term applicable to the zoophytes which, in a fossil state, compose this genus: the generic characters of which are, that they consist of *cylindric, hollow, erect, parallel, aggregated tubes.*

These tubes, which in the recent coral form the habitation of an animal, most probably of the polype kind, are in the fossil filled, in various degrees, with calcareous, argillaceous, or silicious matter, separate or combined. In some specimens, in a transparent, crystallized, and in others in an opaque, amorphous state.

The organ-pipe coral, *(tubipora musica*, Linnæi,) so well known and so much admired by collectors, for its curious form and beautiful red colour, is, I suspect, not known in a mineralized state. The contrary having, however, been very generally supposed to be the case, I have thought it necessary to be rather particular on this head.

Dr. Woodward describes " a coralloid body, excepting the colour, which is grey, resembling the *tubularia purpurea* of Ferrante Imperato. Found in the rubble of a lead mine, near Charterhouse, Mendip, Somersetshire."* But from the negative evidence of almost every other writer; and from a careful examination of the various fossil tubipores, in different collections, I am led to suppose, that the organ-pipe coral is rarely met with in a mineral state. The specific character of this coral is that of being formed of tubes, connected in bundles, by distant, transverse, membranous plates; and, as has been shewn by our celebrated countryman Ellis, when an opening is made into these tubes, they are found to be jointed and to communicate with one another by means of geniculated pipes, which pass through each of them, and are radiated at their joints.† The transverse partitions, or plates, by which the perpendicular pipes are connected, appear also to serve the purpose of supporting the lateral connecting pipes. The different parts here alluded to, are represented Plate III. Fig. 2, in a figure taken from the twenty-seventh plate of the work to which we have just referred. In this representation, the internal pipe may be seen dilating, and then radiating into several small pipes, which pass through the connecting plates. This figure is introduced here for the purpose of affording the more easy comparison with those fossils which have been supposed to belong to this species.

The fossil which approaches the nearest to the *tubipora musica*, is that which is represented Plate I. Fig. 1. It is imbedded in a dark brown lime-stone, from Derbyshire; the substance of which is almost entirely formed of this tubipore, as may be seen, by the quantity of projecting portions on the upper and on the fore part.

In this fossil there are several circumstances, in which an agreement may be observed, between it and the organ-pipe coral; yet, in other

* Dr. Woodward's Catalogue, Vol. II. Page 12.

† The Natural History of Zoophytes, by John Ellis, and Daniel Solander, M.D. P. 143.

respects, the difference is so considerable, as fully to authorize the considering of it, as of a distinct species. The perpendicular pipes are similarly arranged, the internal pipes are also observable, and the lateral communication takes place nearly in the same manner; but here there are no continuous, connecting plates. By an attentive examination of the figure, the lateral openings disposed round the tubes will be observed, through which the transverse pipes of communication passed, in the same manner as in the tubipora musica, except being unaccompanied by the horizontal plates. In this circumstance, therefore, the specific difference exists between the recent tubipore and the fossil species here delineated; and which may be described as a tubipore *composed of erect parallel tubes, including others, which by frequently radiating connect the whole.*

Specimens of this tubiporite are also found in Derbyshire and in Wales, imbedded in a soft matrix from which it is easily detached. In this state, its resemblance to the *tubipora musica*, is still more striking, than when imbedded, as in the above-mentioned specimen. These specimens are, in general, of a dark brown colour; but one in my collection still bears a slight reddish hue, from which their original red colour may be inferred.

In the greater number of these specimens, so much silex enters into the composition of the fossil, as to render it capable of scratching glass, and of resisting the action of the muriatic and nitric acids. The representation of the separate tubiporite is not given, as its figure may be easily imagined from the appearance it yields in the imbedded specimen, Plate I. Fig. 1.

In a marble formed by this species of tubipore, Plate I. Fig. 2, a reddish tinge is observable, which evidently proceeds from some of the original colour of the coral having been preserved. This is rendered indubitable by a close examination of the specimen itself, since it is there seen, that the colour does not exist in the intermediate calcareous matter, or in that which has been introduced into the cavities

of the tubes, but in the substance of the coral, forming the sides of the tubes.

It appears, from the experiments of Mr. Hatchett, that the colouring matter of the organ-pipe coral is similar to that of the red coral, *(gorgonia nobilis,)* being some unknown modification of animal matter. The red colour of both these substances having been gradually destroyed, during the action of the diluted nitric acid, as the solution of the calcareous substance advanced; and could not afterwards by any means be restored: nor could any colouring principle whatever be detected by the re-agents usually employed.*

We also learn, from the Count de Marsilli, that by digesting red coral, with and without its membranaceous tunic, in milk, over a slow fire, the colouring matter was dissolved by the milk, which became thereby of a pink colour; whilst the coral became first of a saffron, then of an ash colour, and at last of a livid white. The same effects resulted from its digestion in heated wax. A similar deprivation of colour is also found to take place in those pieces of coral, which, having been broken, have fallen into, and have remained for some time in the mud at the bottom of the sea.†

As the colouring matter of these corals is capable of being thus removed by digestion, it is not to be wondered at, that, in general, in the fossil specimens, which must, in most instances, have been exposed to long continued maceration in water, little or none of the original colour remains.

From the weight and other physical characters, as well as from exposure to chemical agents, I found that every fossil of this species in my collection, not imbedded in stone, contained too much silicious matter, to admit, by the agency of an acid, the examination into the change which had taken place in the original constituent parts of the coral.

* Philosophical Transactions, for 1800.

† Histoire Physique de la Mer, par Louis Ferdinand Compte de Marsilli.

Indeed, considering that, in the experiments of Mr. Hatchett, even the recent tubipore lost its colour, and only demonstrated some loose particles of a tender membrane, I regarded it as almost hopeless to attempt to detect any animal matter, in a fossil body, which must have existed, in a mineralized state, several thousand years; but as the result, if successful, would prove highly interesting, I resolved on the experiment.

A fragment of the marble, Plate I. Fig. 2, was therefore exposed to the action of the muriatic acid, in a very diluted state. As the calcareous earth dissolved, and the carbonic acid gas escaped, I was much pleased to observe the membranaceous substance appear, depending from the marble, in light, flocculent, elastic membranes. Many of these, most unexpectedly, retained a very deep red colour, and appeared in a beautiful and distinct manner, although not absolutely retaining the form of the tubipore. A faithful representation of this preparation is given, Plate I. Fig. 3.

Tubipora Strues, as described by Linnæus,* appears to agree exactly with the fossil from Westmoreland, Plate II. Fig. 1. Like that tubipore, it is formed of diverging tubes, which are connected by single tubules passing in a horizontal direction from one tube to another; but at much greater distances than either in the *tubipora musica*, or in the fossil last described.

In this specimen, the tubes are seen diverging and bending their course in different ways. The tubes are all filled with calcareous matter, so that their terminations generally present the appearance of a projecting body: in some few only, are the vestiges of an opening discernible. The external surface of the tubes has a scabrous appearance, very much unlike the smooth surfaces of the recent tubipores.

* T. tubis distantibus divergentibus liberis posterius sæpius flexis: tubulis minoribus simplicibus horizontalibus combinatis.—Systema Naturæ, Linnæi. 1788. Tom. IV. P. 3755.

The polished surface on the other side proves that the stone is almost entirely formed by this fossil: and the internal view of the tubes which is thus obtained shews, that the tubipore was formed of hollow tubes, which are now filled with clear spathose matter; and that there is no appearance of that internal structure which is observable, either in the tubipora musica, or in madrepores. In some parts, may be seen, sections of the transverse pipes, which preserve the communication between the several perpendicular tubes.

The appearance of this tubipore differs considerably in different specimens. In a beautiful white specimen, evidently of the same species, from the Marquis of Donegal's Collection, the general appearance differs much from the preceding fossil, Plate II. Fig. 1, partly from the elegant plumose forms, which the ramifications have assumed; and partly from the whiteness of the earth, and the pureness of the spathose matter, with which it has become impregnated; it being a beautiful white marble. The characteristic, minute, transverse, connecting branches are very numerous and conspicuous, and plainly evince the species to which it belongs. Dr. Woodward describes a specimen which appears to belong to this species of tubipore. His description of it is, "a fasciculus of several pieces of a grey coral, lying generally parallel, and held together by means of several small branches passing from one to another, and uniting where they meet. The whole somewhat resembles the tubularia purpurea of Ferrante Imperati: and the stems of this are of the thickness that those of that commonly are. Some of them are tubular; others solid. Found near Sedberg, in Yorkshire."*

* Catalogue of Fossils, Vol. I. Page 130, E. 4.

LETTER V.

RAMIFIED TUBIPORE.....SILICIFIED TUBIPORE IN LIME-STONE..... MARBLE FORMED BY THIS TUBIPORE......CHAIN CORAL......STELLATED TUBIPORE, &c.

THE specimen delineated, Plate III. Fig. 1, and which, I am informed, was found in the neighbourhood of Mendip, in Somersetshire, differs from the fossil specimens already figured, and from the recent tubipore, in having neither horizontal plates, nor horizontal pipes, to secure the necessary communication between the different parts of the animal, disposed in the several tubes of which the tubipore is composed. This office appears to have been accomplished in the species of tubipore, to which this specimen belonged, by the simple mode of small ramifications, passing from one branch to another; not, as in the species already described, in a horizontal, but in an oblique direction. As far as can be ascertained by this specimen, the ramifications appear to have been dichotomous. This species, which it seems might be properly termed *tubipore ramulosa*, may be described as *composed of tubes connected by dichotomous ramifications*.

A very curious circumstance is observable with respect to the particular specimen which is here figured. It has been remarked, that the fossil specimens, already mentioned, are sometimes formed almost entirely of flint; and the necessary examination shewed that, in the present fossil, every part of it which had been coral, as well that part which was imbedded in the stone, as that which projected from its surface, was in a high degree silicious; whilst the stone which contained it was pure lime-stone. In consequence of this the stone being briskly rubbed on a silicious sand-stone, those parts

which had been formerly organized, acquired a considerable polish, and projected beyond the general surface, which was more rubbed down, and which, although somewhat smoothed, had not obtained any polish. The difference of the two substances was more accurately determined, by immersing this same surface for a few minutes in marine acid, since although a considerable degree of effervescence, and a removal of some of the substance, evinced its action on the interposed lime-stone, no trace of its influence on the polished projecting parts was discernible ; even the polish was not in the least impaired.

To what a remote period of past time, and to what astonishing changes in the structure of the surface, at least, of this globe, does this circumstance direct our contemplation! A body, differing from any animal substance now known, has been formed, by the energies of animal life, in the depths of the ocean of a former world ; and is now found imbedded in a rock, many miles inland, and at a considerable height above the sea : and these, wonderful as they are, are not the only circumstances of this case, which, in the present state of our knowledge, may be considered as inexplicable. The substance, of which this body is composed, has undergone a most extraordinary change : originally formed chiefly of carbonic acid and lime, with a small portion of animal matter, it has now become a mass, in which, except perhaps a portion of animal matter, these substances are no longer to be found : the space of which was formerly allotted to them being now filled almost entirely with the earth of flint ; and to add to the wonder, the silicified mass is found imbedded in lime.

In what situation this body was placed at the period it suffered this change of its substance? By what process its original constituent principles were removed, and those of which it is now composed were added, and how so great a change could be effected, with apparently no alteration whatever of its form?—These are questions which perhaps cannot be answered, until a considerable farther advance is made

in the progress of this science, and until it is known by what agent the earth of flints has, at some former period, existed so generally and so plenteously in solution.

The specimen of marble, Plate III. Fig. 3, from Wales, evidently owes its configurations to this tubipore. In several parts may be seen different sections of the tubes, filled by white spathose matter. In some parts of marble, sections of the connecting branches may also be perceived; by which it appears, that they exactly agree, in their mode of ramification, and in the direction which they preserve, with that which is observable in the specimen, Plate III. Fig. 1.

The next species of the genus tubipore which claims our notice, is the CHAIN CORAL, *(tubipora catenulata*, Linn.) composed of parallel tubes, formed in laminæ anastomosing by their winding folds.

This curious zoophyte has been only found in a fossil state. The flattened oval tubes, of which it is composed, being placed perpendicularly in a waving line; finely grooved, thin, upright folds, are formed by the sides of the tubes, whilst their upper, and oftentimes their lower, surfaces, present an appearance exceedingly resembling that of a small chain. Its appearance is frequently so beautiful as to resemble figures, formed by the tool of the most delicate workman, or by the needle of the embroiderer: and the folds, by frequently coming into contact with each other, make it appear as if the chain was so connected as to form a net. This curious reticular form, as is observed by Bromell, does not yield a bad representation of a retiform plexus of lymphatic vessels.*

The folds of this coral are of various heights: they, oftentimes, are not more than a quarter of an inch in height; and seldom exceed six inches. The interstices between the folds of the coral, as well as the tubes themselves, are generally filled up with a mixture of argillaceous and calcareous earth. A considerable difference, however, is found in the matrix in which different specimens of this fossil

* Bromellii Lithograph. Vide Spec. 2, 25. Tab. 25.

are imbedded. In some, it is composed chiefly of brown argillaceous matter; in others, it is a pretty solid lime-stone; whilst, in others, it is formed of very fine particles of both argillaceous and calcareous earth. The coral itself often varies in its colour and hardness. In some specimens it is of a yellowish hue, and in others of a bluish white. In some it is much harder and firmer than the investing matrix, whilst, in others, possessing a spathose texture, it is much more fragile. This coral is generally opaque and white; but sometimes it has sufficient transparency, to allow the transmission of the light through a thin section of the mass, so as to render the parts of the coral visible, as is shewn, Plate III. Fig. 6.

In the specimen, Plate III. Fig. 4, the tubular folds reach sufficiently above the matrix to afford a fair view of their structure. The grooves formed on the external surface, between the prominences occasioned by the tubes, are very plainly to be observed. Slight horizontal lines crossing the former may also be perceived: and with the aid of a lens, these manifest the appearance of having been formed by regular additions of fresh matter, applied by the inhabitants of the tubes, during the several stages of their growth. Minute openings are also observable in the sides of the tubes, by which it is probable, that a connection was preserved betwixt all the parts of the animal mass with which the tubes were filled.

The specimen, Plate III. Fig. 5, very much resembles that which is figured by Bromell, and which he so properly describes as approaching in its appearance to a reticular plexus of lymphatics. The white coral being contrasted by the dark ground, yields indeed a very beautiful appearance, and gives also the idea of the laboured works of some nice artist.

Tubipora serpens, as appears from the figure and description given by Fougt* of the fossil referred to under this head, can hardly be

* Amœnit. Acad. Tom. I. P. 105, Tab. 4. Fig. XXVI.

considered as a tubipore. The other references, in illustration of this species, by Gmelin, appear to be incorrect.

Fascicular tubipore *(tubipora fascicularis*, Linn.) described by Fabricius as being formed of fasciculated filiform tubes, anastomosing in places, at their sides:* and found in a mineral state on the shores of Gothland, and in the lime-stone mountains, of the size of a sparrow's quill, has not, I conjecture, been yet figured. Nor have I to my knowledge yet seen this fossil.

Tubipora ramosa, T. pinnata, T. pennicillata, and T. flabellaris, have not yet been seen in a fossil state. Indeed, that minuteness of the parts of which they are composed, their structure, and various other circumstances, demonstrate the little probability there is of these substances being detected, after they have become a stony mass.

Stellated tubipore, *(tubipora stellata*, Linn.) is described by Adrian Modeer† as a fossil found in the Swedish Island, Gothland. It is formed by distinct tubes, combined in ranges, by many remote platforms; formed of horizontally disposed plates, with radiating striæ on their surfaces, and pierced for the passage of the tubes. This fossil, from the description, and from the plate which is given of it by Modeer, appears to be fully deserving to be considered as a distinct species. That curious species of communication between the several parts of the animal, which has been already noticed in the organ-pipe coral, as being kept up by radiating tubuli, passing through the substance of the horizontally disposed plates, appearing in this species to be carried on by similar pipes passing either through divided plates, or on the surface of the plates, forming on them the radiated striæ just described.

* O. Fabr. Fn. Groenl. 429.

† Act. Stockholm. 1788. § 4. No. 1.

LETTER VI.

MADREPORE......MADREPOREAN POLYPE......FOSSIL MADREPORE...... DIFFICULTY IN ASCERTAINING THE SPECIES......TURBINATED MADREPORE......VARIETIES OF......REMARKS ON ITS FORMATION.

We shall now proceed to the examination of the genus Madrepore, under which genus are placed all those corals, the cavities of which are divided by lamellæ disposed in a stellular form.

The animal which in the recent coral fills these cavities, was first depicted by Donati, in the forty-seventh volume of the Philosophical Transactions, Page 105, Plate IV. and in the Natural History of the Adriatic Sea, by the same Author. A correct copy of Donati's figures are here given, since you will thereby be better enabled to judge of the observations I may offer respecting the formation of some of these fossil bodies which are next to be examined.

The little polypous inhabitant of the madrepore, Plate II. Fig. 2, 3, 4, according to the concise but perspicuous description of Donati, is composed of three different parts; the feet, the shell, and the head. The feet are in considerable number, and terminate externally in two conical productions, which being placed on each side of every one of the lamellæ which give the stellular form to the cavity of the coral, serve to affix the animal to the circumference of its cell, and may, with propriety, be considered as the instruments by which the little animal forms the lamellæ themselves. The other end of these conical productions unite and form round bodies, which possess somewhat of the figure and of the properties of a muscle; they undoubtedly serving to lengthen or shorten the feet, and also most probably to regulate the

force with which they clasp the lamellæ, on which they exert their plastic powers. The other ends of these round bodies terminate in small cylindric tubes, which are attached to the shell of the animal, in the centre of which is seen its head, capable of moving with great quickness, and ornamented with several rays, which are most probably the arms or claws with which it seizes and secures the animalculæ on which it feeds.

The great number of species under the genus madrepore, and the near approach in many respects of these species to each other, render the separation of them, even in a recent state, very difficult, unless by the aid of perfect specimens. But when we take into consideration, the minuteness, as well as the extreme delicacy, of structure, of those parts, from which their specific and even their generic characters are deduced in many corals; and, also, reflect on the vast changes which the fossil has undergone, and the injuries to which it may have been exposed through countless ages, it must be evident, that it will be frequently very difficult to trace the mineralized madrepore to its recent analogue. Many also of the recent corals are not known in a mineralized state; and among the fossil corals there are also many, which cannot be referred to any known recent species. Under these circumstances, I think it necessary to apprize you, that a much less degree of correspondence will be made out between the recent and the mineral corals than you might have expected.

From this, however, I trust more of gratification than of disappointment will proceed. More of the inexhaustible riches of creation will be displayed; and sufficient proofs will be found among this class of animals to determine, that the creative powers of nature have not been confined to the forming of such animals only as now exist.

Agreeable to the arrangement of Linnæus, we shall commence with the examination of the simple madrepores, *those which are formed of a single star.*

The top-like madrepore *(madrepora turbinata)*, Plate IV. Fig. 1, 2, 3, &c. smooth, with a concave hemispheric star, is a zoophyte, only known in a mineralized state.

This species of madrepore has in general a conical figure, the lower part of the cone being often very much contracted, as if to form a pedicle. From this point, the body of the fossil gradually enlarges, until it terminates in a truncated apex; or is previously prolonged into a cylindrical oblong body. In either case, the surface is divided by numerous, small, and hardly perceptible longitudinal striæ, and girt with transverse, obtuse, and unequal furrows.

The star which fills the apex is concave, and formed by sulcated, or lamellated, and frequently even, dentated rays, proceeding from the central depression to the edge of the cavity, which is generally acute.

These fossils are commonly formed of a lime-stone, which, in general, is internally of a light, or yellowish brown colour; but they are mostly externally of a bluish grey, deriving this colour from the matrix in which they have been imbedded.

These madreporites vary much in size; some hardly exceeding that of a horse-bean; whilst others are three or four inches in length, and others of even nearly that diameter.

No investigation respecting these fossil substances has been conducted with so much success as that which has been instituted by the learned author of the Dissertation on the Baltic Corals. Nor can the figures with which he illustrates the several varieties of this species of madreporite be exceeded, in exactness of representation. To atone, therefore, to those who have it not in their power to refer to those figures, for their repetition here, I have, as I have in every other parallel case, endeavoured to select such specimens for the engraver, as may serve also to point out some important circumstance to which the figures in former works do not refer.

The corallite represented at Plate IV. Fig. 2, differs, in its figure, from the other corallites of this species; having somewhat of a discoid appearance. This difference, I suspect, has depended entirely on the age of the coral: the labours of the little modeller not having been here so advanced as in those which have the turbinated shape. In this specimen, the diameter of the disk more than equals the height of the coral: the depth of the stellated cavity is therefore necessarily small. The rays pass from the centre of the cavity, and terminate in the margin; which appears to be preternaturally thick, from its edge having probably been somewhat worn down, by rolling on the shores of the Baltic, whence it was obtained. From the same circumstance, perhaps, has proceeded the flatness of the stellated surface; the projecting parts of the radiating lamellæ having been also worn down. Sufficient, however, remains, not only to convey a correct idea of the structure of the fossil, but to shew that it was a dwelling exactly fitted for the accommodation of the animal described by Donati, as the inhabitant of madrepores.

By a careful inspection of many of these madreporites, I have learnt, that they have been attached to the substance on which they have grown, by tubes bearing the form, and so far performing to them the office of roots, as to secure them from easy removal from their native spot. This pedicle I consider as an essential part of these animal substances; and I trust, I shall be able to establish its existence sufficiently often, to warrant the assumption of its having existed in all those bodies in which it cannot be directly manifested, but in which its admission will render their nature much less difficult to understand.

On the reverse, or inferior side of this fossil, longitudinal striæ, answering to the internal radiating laminæ, may be easily traced; and are intersected by distinct transverse ridges and grooves, marking the progressive increase of the madrepore by the successive labours of its

polype. In the centre of this part of the specimen, the base of the root may be observed; the root itself, with its surrounding processes, having been bowldered down nearly smooth.

Plate IV. Fig. 1, represents a variety of this species, which has acquired more of a pyramidal form; its body having been so elongated as to have terminated almost in a point, where the root has evidently been broken off. The remains of the root are, however, still observable, and are surrounded with several processes, the appearance of which sufficiently evince that their office was to assist in affixing the plant-like habitation of the animal to its destined spot.

A circumstance which particularly claims observation in this species of madreporite, is, that of a second coral proceeding, in the manner of proliferous flowers, from the disk of the first. In the specimen, Plate IV. Fig. 3, a separation may be seen of about half the circumference and nearly of half the diameter of the coral. The commencement of a similar process is observable in several other specimens. The specimen, Fig. 5, has obviously obtained its increase in this manner, by the formation of fresh corals from the disks of the preceding.

The size of these corals, as has been already observed, vary considerably: indeed, I suspect that I have seen some from Derbyshire, even upwards of a foot in length. Equally considerable also is the variety of forms which they assume. In some the shape is completely turbinated: in others the length is considerably protracted; sometimes in a straight, and at other times in a curved direction, as at Plate IV. Fig. 8. The polished longitudinal section of this fossil shews the internal part of the madrepore to have been divided by transverse lamellæ, which correspond with the circular projections on the surface. Such of these fossils as possess a curved form are frequently of a considerable size, sometimes nearly approaching even to the magnitude of a bullock's horn. In a specimen from Perthshire, lately offered to me for examination, not only the form of the goat's or ram's horn, but the colour, and even somewhat of the disposition

to transparency similar to that of horn was observable. These circumstances have also been observed in the madreporites of Gothland. But those which are generally met with in this island are of a dark ash colour, the ridges, however, of these, formed by the transverse plates of the corals, give them very much of the appearance which has just been noticed.

Attributing the formation of these corals to the operations of the madreporean or medusean polype, let us endeavour to trace the little architect through its wonderful labours. Agreeable to the observations of Donati, each of the legs, as he terms them, of the polype are provided with two processes which are applied to each side of one of the perpendicular laminæ, whilst a muscular pyriform body, attached to the other end of the leg, gives to it the power of employing that motion which is necessary for the accomplishment of its task. The young polype, disposed on an appropriate spot, may be considered as completing its operations by two distinct processes: the secretion and separation of carbonate of lime from the sea-water, conveyed through the pyriform body; and its deposition, at its moment of secretion, by the two small processes, where the economy of the animal directs. Proportioned to the number of legs possessed by the infant animal, was probably the number of perpendicular laminæ, or pillars converging to the centre, which it began to erect; these when raised to a certain height, appearing to have been connected together by a horizontal plate of the same substance. On these the animal erected similar pillars, and placed on these a covering similar to that with which he had completed the first compartment. Thus seems to have proceeded the incessant labours of the minute artist: and as the number of its legs, or instruments, increased, and as they extended in length, so must the number of the perpendicular laminæ, and the circumference of the horizontal plates have also augmented. Thus must this curious fabric have derived its fashion from the growth and form of this minute and wonderful animal.

That the formation of these turbinated madrepores may have been thus effected does not appear difficult to conceive. Neither is it difficult to understand, that when the animal had attained its full extent of growth, the continuance of its labours would produce, not a body of a conical, but of a cylindrical form. Nor does it appear unlikely that should any accidental circumstance change its horizontal position, a proportional deflection from the straight line would be occasioned; and a coralline body of a curved form be produced. Specimens of both these forms, it has been just remarked, are frequently found.

The appearances yielded by two sections of this species of madreporite are represented, Plate IV. Fig. 13, 14. Fig. 14, is a section made at about an inch from the pedicle, and Fig. 13, is a section made after the madrepore had assumed a cylindrical form. In the former of these it will be observed, that both the converging and the concentric laminæ are much fewer than in the latter. In consequence of this, a considerable degree of dissimilarity is observable between the two specimens; which indeed leads to observations respecting the labours of the insect, and the structure of the coral, which were they not here out of place, would be right to pursue.

LETTER VII.

OBSERVATIONS ON TURBINATED MADREPORITES CONTINUED..... PORPITAL OR SHIRT-BUTTON MADREPORITE.....SYNONYMA MADREPORES NOT FOUND IN A MINERALIZED STATE.

Hardly any of the animalized parts of the creation are arranged with more difficulty than those remains of zoophytes which are obtained in a fossil state. The labours of the little creatures by which they have been modelled, frequently appear as if they had been capriciously and sportfully performed; deviations from their ordinary model, apparently unnecessary, being frequently to be observed. The avoiding, perhaps, of some little obstacle to their labours, the repairing of some little injury, which accident may have occasioned to their operations; or many other circumstances, not to be ascertained, may have occasioned these departures from the usual mode in which they had been wont to execute their assigned task. Hence the substances which they have formed may possess such anomalies of form, as may render it difficult to determine whether they should be considered as specific characteristics, or only as such accidental modifications of the structure of a species as give rise to varieties. The difficulty of making the necessary distinction, in these cases, must necessarily be much greater when, as is frequently the case with fossil specimens, we are deprived of the advantage of comparison, by having only one specimen on which to exercise our judgement. Especially since it also often happens, that its characteristic marks have been, in a great measure, effaced by the injuries to which it has been exposed, during a period of several thousand years.

Fig. 4, of Plate IV. is the representation of the stellated surface of a madreporite, of a form sufficiently distinct from that of any other to allow of its being considered as a distinct species, should its frequent appearance in other specimens give reason to suppose that it had a constancy of character, and that it did not result from an accidental or sportive variation in the erection of the polypean fabric. The perpendicular laminæ have united in two lines, which, by crossing each other, have so quartered the star, as to have made it yield the appearance of a flower with four expanded petals. The other part of the surface of this fossil has been so rubbed down by attrition in the water, as to have deprived it considerably of its natural appearance. Its general form, however, is that of the turbinated madrepore.

The star with a convex surface, represented Plate IV. Fig. 7, appears to be the impression on lime-stone of the upper surface of a turbinated madreporite. The calcareous spathose particles having been deposited in all the hollow parts of the coral, and having become firmly indurated, have retained the form which they thus assumed, whilst the madrepore itself has been removed.

The *Fungites major orbicularis Gothlandicus*, figured by Langius * and by Bromell ;† and placed under this species by the author of Corallia Baltica, and in the Systema Naturæ of Linnæus, by Gmelin, I shall venture to place among the mineralized alcyonia ; trusting that in its proper place I shall be able to shew the propriety of this dissent from authorities so high and respectable.

There are among the fossil single starred corals, some which, with the general form and other specific characters of the turbinated madrepore, possess also some other distinctive characters, which, from their constancy, seem to point out these corals, as deserving to be considered as so many distinct species.

* Historia Lapidum Figuratorum Helvetiæ, P. 52. Tab. 12.

† Bromel. Lithog. Sp. 2. 36.

Plate IV. Fig. 16, is the representation of an elegant corallite, from the chalk-pits, at Northfleet, in Kent, attached to the chalk in which it was found imbedded. Its root, which is adherent to a plate of echinus, is regularly indented with angular excavations, which appear to be about eight in number. From the root proceeds the body of the coral, gently bending and gradually enlarging into a conical form, about an inch in length. Its under and external surface is elegantly striated with distinct ridges, regularly disposed in the following order: midway between every two of the largest ridges is placed one rather smaller. The star on the disk *(a)* is formed by perpendicular lamellæ, reaching from each of the largest ridges on the circumference, to the centre, and by smaller lamellæ proceeding from each of the ridges of those of a smaller size, but which reach a very little way towards the centre. As there are no transverse ridges on the external surface, so there are no horizontal plates observed internally, at least as low as the eye can command, which is very near to the bottom.

The specimen, Plate IV. Fig. 15, is also from the chalk-pits, at Northfleet. In this delicate specimen, the pedicle is very observable; the ridges, on the external surface, are all nearly similar in size, and disposed with much regularity and neatness. The stellated disk *(b)* is formed by perpendicular plates, answering to each of these ridges, and nearly meeting in the centre.

The madreporite, Plate IV. Fig. 9, which I have reason to believe to be an Italian fossil, is in the form a flattened cone: at the point of the cone appears to have been a pedicle, from which proceed innumerable striæ which terminate in the other end of the cone: where a star is formed, which differs materially in its form from any which have existed in the specimens hitherto mentioned. From the inner sides of the cone proceed perpendicular plates which meet, not in a point in the centre, but in a line, possessing about three-fourths of the centre of the longest diameter of the base of the cone.

The appearance which this fossil bears might convey the notion of its having suffered by compression. But this is rendered highly improbable, by the circumstance of coral obtaining such a degree of hardness, at its first formation by the animal, as would effectually oppose any attempt to change its form, except by fracture. That many substances, originally hard and unyielding, may, during the changes they undergo in the progress of their mineralization, become soft and compressible, is very probable; but there is nothing in the appearance of this fossil to warrant the suspicion of its having been thus affected. The mode in which the perpendicular laminæ terminate serves also to determine the question: the line in which they end, in the centre, being exactly appropriated to that form which the fossil bears; and which therefore may be concluded to have been its original and natural form. It is also deserving of particular notice, that the *parietes* of this corallite are remarkably thick and dense.

In the fossil, represented Plate IV. Fig. 7, a turbinated madrepore, the perpendicular lamellæ of which are rendered visible by the decomposition and removal of its external coat, is seen blended in the same mass with the remains of the encrinus. In Plate III. Fig. 4, a corallite of this species is seen attached to the mass of chain coral, exemplifying the proverb, *Noscitur ex sociis*, three different species of animal remains, whose originals are unknown to us, being thus found associated.

A complete and rare specimen of marble from Blankenberg, formed by this species of madrepore, is shewn, Plate IV. Fig. 17. Not only is the form of the disk well preserved, but even the internal structure of the madrepore may be here perfectly made out.

The next species of madrepore which demands our attention is the shirt-button madrepore *(madrepora porpita*, Linn.). This is a flattish orbicular body, smooth on the inferior surface, being marked there only by very minute circular lines and perpendicular striæ, and having, on its disk, a star, somewhat convex towards the edge, but

hollowed out towards the centre. The rays composing the star, and which converge from the edge towards the centre, are dentated and are of two orders; the larger being placed alternately with the smaller. The representation, Plate IV. Fig. 6, yields a very correct idea of the appearance presented by the disk of this fossil.

Whilst examining the various specimens of fossil madrepores in my possession, I was very much struck with the beautiful appearance of the turbinated madreporite from Sweden, which is figured Plate IV. Fig. 11; and particularly observed, that the rays had an appearance totally different from those of any other which I had noticed. The form of this madreporite places it indubitably among the turbinated madrepores; it gradually narrowing and terminating in a curved pedicle. Innumerable striæ, which are intersected by horizontal ridges and depressions, most closely and neatly arranged, mark the whole of its inferior surface.

The disk derives a rich appearance from the perpendicular radiating laminæ which form the star, being arranged alternately in a larger and smaller size, and being also closely beset with rounded annular protuberances; the whole of the superior part of the coral bearing an exact resemblance to the disk of the porpital madrepore. Indeed, so exactly does it resemble this fossil, that I feel no hesitation in considering them as being both of the same species; and as differing from each other only in their having undergone the lapidifying process at different stages of their growth. Nor do I perceive in the porpital madrepore the least reason for doubting that it possessed a pedicle of the same kind with the larger specimen; but being proportionably less, it must have been so much more liable to be removed.

The celebrated Linnæus has considered the absence of a pedicle in this madrepore as one of its first specific characters. It is considered and described, both by Buttner and by Bromell, as the head or top of some small marine fungus: neither of them having discovered any remains of a pedicle by which it could have been attached to

other bodies. The author of *Corallia Baltica* very justly observes that, notwithstanding the strength which the opinion derives from this circumstance, there undoubtedly exists sufficient reason for dissenting from it.

The fossil, Plate IV. Fig. 10, from Gothland, possesses, like that at Fig. 11, all the characters of the porpital madrepore on its disk, but having its body extended into a conical shape, forms, as it were, the link which connects into one species, the porpital madrepore and the madrepore just described.

The most curious fossil which I have seen of this kind, is one which I obtained at the sale of the Leverian Museum. It has the complete external characters of the porpital madrepore; but is perfectly pellucid, being formed of a fine transparent calcareous spar.

These corallites have received various names from the older oryctologists. When the turbinated madrepore was formed of conical or cylindrical pieces connected by seeming articulations, and possessing a stellated cavity at one of its terminations, it was named *hippurites corallinus*, *calix hyppuriticus*, and *corallia geniculata*. By Bromell, Langius, and others, all those of a more compressed form have been named *fungites;* and that, not merely from their resemblance to mushrooms, but from their having been actually supposed to be those vegetable substances, in a state of petrifaction. Dr. Plot, and others, have distinguished those which have possessed more of a cylindrical form by the name of *columelli;* and Lhwydd has applied to them the name of *columnetæ:* both terms being diminutives of *columna*, and intended to mark their resemblance to a little pillar. From the similitude which they bear to horns they have also been termed *ceratitæ recti et incurvati*. Dr. Woodward comprehends both the turbinated and the porpital madrepore under the term *mycetitæ coralloides;* distinguishing the former into *mycetitæ conoides*, *seu calyciformes*, and the latter into *mycetitæ discoides*.

With respect to the *madrepora fungites* and *madrepora patella*, I do not know of any corresponding fossil. To the *madrepora cyathus* of Ellis, the last of the single starred corals, which is also figured by Count Marsilli* and Plancus,† the fossil figured Plate IV. Fig 5, bears some resemblance; but the agreement, however, is by no means sufficient to authorize the belief that they are of the same species. In the specimen figured by Ellis, the lamellæ are forty in number, with as many intermediate small ones; but the lamellæ in this fossil do not come near to that number. This indeed is of itself a circumstance which would be but of little weight, if their other characters closely agreed. This corallite which is attached to its matrix, a piece of lime-stone, composed of minute fragments of marine bodies, bears, in its first joint, indeed, some resemblance to the *m. cyathus;* but it is, as may be seen in the figure, a proliferous coral, which circumstance is not referred to by either Plancus, Marsilli, or Ellis, in their accounts of the recent coral.

* Histoire Physique du la Mer. P. 153.
† Planc de Conchis minus notis. P. 112.

LETTER VIII.

OTHER MADREPORES, NOT PERHAPS KNOWN IN A FOSSIL STATE.... MADREPORA FAVOSA....MADREPORA RETEPORA....M. ANANAS, &c. M. FOLIOSA, &c......ASTROITES.....LITHOSTROTION OF LHWYDD..... SPIDER STONE OF BRUCKMAN.

We now proceed to make inquiry respecting the fossil remains of those madrepores which are composed of many stars. The first of these in the Linnæan order of classification are those which are concatenated and formed by disjoined stars, with continuous lamellæ.

These are *madrepora pileus*, *m. cristata*, *m. lactuca*, *m. ficoides*, *m. acerosa*, *m. lichen*, *m. agaricites*, *m. elephantotus*, *m. crustacea*, *m. incrustaus*, *m. exesa*, *m. filograna*, *m. natans*, *m. anthophyllum:* but I have not been able to discover any of the remains of these in a mineralized state.

Those madrepores, which are distinguished as being conglomerated, the stars of which are united together, form the next objects of our inquiry. Of these, *madrepora labyrinthica*, which has no stem, and the stars of which are divided by obtuse sutures, extended in labyrinthian windings, I have more reason to suppose may exist in a mineralized state. From the form of this coral, which is generally approaching to a hemisphere, and from its upper surface, which is marked with convolutions much resembling those of the brain, it has acquired the common appellation of *brain-stone*. This coral is chiefly found in a recent state on the rocks which surround the West-India islands. But I have repeatedly seen among the bowlders with which some of our streets are paved, and which I am informed are chiefly

obtained from Hudson's Bay, pretty large specimens of this coral very much changed by the decomposition of their surface, either by long exposure to the action of water or of air, after having lost their inhabitants, or by having been buried in the earth. The change, in such specimens as I have broken, did not, however, appear to have extended to such a depth as to have allowed the classing them amongst the fossil corals. Boetius de Boot gives the representation of a specimen evidently bearing the figure of this coral, but which from the form and size, which it appears to have derived from the labours of the artist, and from its having been considered by the author as deserving to be ranked among the gems fit to be worn as ornaments, there is good reason for believing it had undergone an impregnation with silex.*

Neither *madrepora sinuosa*, nor *m. mæandrites* appear to have been described as having been seen in a mineralized state. A specimen of *m. areola*, now before me, the history of which is unknown, bears such marks as give considerable reason for believing it may with propriety be considered as a fossil. Its inferior surface has evidently much suffered from decomposition, the effects of which are still more plainly observable on the superior surface, and particularly on the feather-like lamellæ, which have acquired an opaque whiteness, and are nearly covered with a whitish-grey calcareous matter, with which the interposed cavities are nearly filled. Although I entertain but little doubt of this being a fossil coral, yet, as it is not incontestibly so, I have not ventured to introduce its representation.

I do not recollect to have seen either *madrepora abdita*, *m. phrygia*, *m. dædalea*, *m. cerebrum*, or *m. gyrosa*, in a mineralized state; and am by no means sufficiently acquainted with the particular forms of *madrepora repanda*, *m. ambigua*, *m. clivosa*, *m. involuta*, *m. implicata*, or of *m. cochlea*, to be able to speak with respect to their existence as fossils.

* Gemmarum et Lapidum Historia. Liber II. Cap. CXLV. P. 297.

We shall now proceed to the examination of aggregated and undivided madrepores, with distinct stars, and with porous and tuberculous *ambulacra*. Previously, however, to commencing this investigation, it is proper to remark, that considerable difficulty frequently occurs in the attempt to discriminate between the different madrepores of this class when fossil. This difficulty, which also sometimes occurs in the class which has just been treated of, arises from the circumstance of the superior surface of the coral, from which its specific characters are chiefly taken, being found covered over, and filled up, with the extraneous matter, so as to be totally excluded from the sight. In specimens of this kind, and which are by far most numerous, no farther knowledge of the form of the coral can be obtained, than what is discovered by sections of the specimen; which being made in different directions, yield information respecting the shape and size of the stars, and the number and extent of their lamellæ. But as it is impossible thus to acquire any knowledge of the superior surface of the madrepore, so an opportunity is seldom yielded for acquiring information of the distance at which the stars are there placed; and never any respecting the peculiar characters of the *lamellæ* or of the *ambulacræ*. Hence permission must frequently be required, in these cases, to substitute analogical inferences for actual observation and comparison.

The figure given by Fougt,* as *madrepora favosa*, represents a fossil so much injured and altered, as renders it impossible to determine to what species it belongs.

The specimen figured Plate V. Fig. 9, bears a very strong resemblance, except that its cells are larger, to *madrepora retepora*. The angulated cells are very similar; but I have not been able, in the fossil specimen, to detect the reteporous structure of the parietes of the cells, which gives name to the recent madrepore. This, however,

* Amœnit. Acad. Tom. I. Tab. IV. Fig. 16.

may be concealed by the spathose matter with which the fossil is penetrated.

The honey-comb appearance of this fossil is very striking. The resemblance which it bears to a honey-comb is indeed sufficiently great to account for, and to excuse the relations we meet with of petrified honey-combs; in which some have even fancied they have discovered the relics of the bees which had perished with their dwelling. So completely is this madrepore mineralized, that the coralline substance of which it was composed is now entirely converted to a spathose matter, exhibiting a shining fracture. So great indeed is the change which it has sustained, that it was not until I had submitted it to examination by a lens, that I was fully convinced that it was not a fragment of the spathose *septa* of a septarium, the *tali* of which had been formed of a loose ferruginous earth. But by this examination the perpendicular striæ on the sides of the tubes were discovered, and the real nature of the substance determined. This fossil was separated from a lime-stone at Masbury, on Mendip, near Wells, by J. Herbert, Esq. of Bristol, a gentleman whose knowledge of extraneous fossils renders his communications highly valuable. This gentleman's liberal assistance I shall have repeated occasion to acknowledge.

Madrepora ananas is figured as a fossil by Bromell, Helwinge, Wolfart, Volkmann, Fougt, and others; but I have not seen any fossil specimen which could with certainty be referred to this particular species.

This coral is composed of angular stars, which, in its recent state, being convex at their edges, and having depressions in their centre and interstices, give somewhat of the appearance of the surface of a pine apple. But in almost all the representations which I have seen of this madrepore in a fossil state, the surface appears to have been so smoothed by attrition, as to render it very difficult to determine to which of the stellated madrepores it belonged. The nearest approach to this madrepore which I have seen, is the specimen from Sweden,

figured Plate V. Fig. 1. It must indeed be admitted that it resembles, in more respects than one, the description given by Helwing of this fossil: "Corallium album superficie figuris asteriformibus propemodum obliteratis."* From the accurate observations of Fougt, it appears that this is a proliferous madrepore, a fresh series of stars proceeding from the centre of the disks of the previously existing stars.†

Madrepora galaxea, *m. faviolata*, and *m. pleiades*, I have repeatedly seen so far decomposed, as to have thereby acquired very much the appearance of a fossil; but this state might have been entirely occasioned by long exposure to the weather, or to the action of water, after they had been deprived of the influence of the living principle. With the forms of *mad. hyades*, *m. latebrosa*, and *m. arenosa*, I am not sufficiently acquainted to enable me to speak with respect to their existence in a mineralized state.

Plate V. Fig. 8, is the representation of a most beautiful specimen of a fossil madrepore from Ribieze, in Transylvania. This coral, formed of cylindrical stars with elevated margins, and having broad concavely sulcated and radiated interstices, bears somewhat of a resemblance to the *madrepora radiata* of Solander and Ellis. The coral has undergone a very considerable change; it being now a carbonate of lime, much more friable than chalk.

Plate V. Fig. 4, represents another specimen from the shores of Lincolnshire, which is so changed as almost to be reduced to the state of chalk. It bears some resemblance to *madrepora annularis* of Solander and Ellis, which appears to be merely a variety of the *mad. radiata*.

Madrepora papillosa, which is allied to, and perhaps is, the *madrepora muricata*, in an incipient, is hardly to be distinguished in a mineral, state. *Madrepora polygama*, in Gmelin's Systema Naturæ Linnæi, is certainly

* Lithographiæ Angerburgicæ. Pag. 53. † Amœnitat. Acad. Fig. VIII. No. 2.

referred to a wrong figure in the Corallia Baltica. Of its existence in a fossil state I am unable to speak. *Madrepora interstincta spongiosa*, does not appear to be known in a mineral state. *Madrepora stellulata*, as well as *m. poculata*, are sometimes seen in a state which would almost incline to the suspicion of their being fossils; but as this state may be induced by other causes, there does not seem to exist sufficient authority for placing them amongst the fossil corals. *Madrepora foliosa*, is very erroneously referred for illustration by Gmelin to Tab. II. Fig. 3 and 4, of Baier's *Monumenta Rerum Petrificarum;* since the figures given by Baier are undoubtedly the representations of an alcyonium, and is indeed designated by Baier as a *fungites striatus*. I do not know of this madrepore having been discovered in a fossil state.

The *madrepora astroites* of Linnæus does not appear to be exactly ascertained. According to the Linnæan description, it is formed of stars very closely crowded together, (stellis confertissimis) whilst the description of Solander and Ellis places *porous interstices* between the stars, and the fossil coral of Mylius, which is referred to this species, has very considerable interstices between the stars. Without dwelling here on the consideration of the recent coral, it is proper to remark, that writers on secondary fossils have frequently applied the term *astroites*, generally, to all such fossil corals as present the appearance of stars collected together; and have very seldom intended to designate thereby any particular species; but, on the contrary, have placed under this title corals, differing very much from each other in size, and in many other respects. Bertrand even considers the *astroites* as of a different family from the madrepores.

No fossil has been more frequently considered as an astroites than that fossil madrepore which has been found so abundantly in some parts of Wales, and which Lhwyd has named *lithostrotion*, *sive basaltes minimus striatus*, *et stellatus*,* from its resemblance, in miniature, to

* Lithophylacii Britannici Ichnographia. Epistol. V. Tab. 23.

the astonishing basaltic columns which form those stupendous masses called the Giant's Causeway, in the north of Ireland, and which also exist in several other parts of the world. The figure of this fossil, given by Lhwyd, yields a correct idea of the manner in which it is amassed together. Volkmann also gives a very accurate representation of the web-like surface which a transverse section of these columns exhibits: and, led by this particular appearance, he names this fossil *corallium arachnion*, *astroites arachnoides*, s. *telis quasi araneis obtextus*, *pentagonus*, *astroites vorticalis*.* Indeed, an examination of the appearance which the stars of this coral yield, especially when magnified, will sufficiently countenance the celebrated Volkmann in hesitating by which term to designate it, since it readily excites both the idea of the web of a spider, and of the figures which have been sketched to illustrate the *vortices* of Descartes.

The lime-stone or marble of which this fossil consists, is generally of an ashen-grey colour, of a compact texture, capable of a good polish, and breaks with a moderate force, laterally applied, into angular ledges. Plate V. Fig. 6. A close examination, especially of its polished surface, (see Plate V. Fig. 3,) will shew that the stone is composed of a congeries of polygonal columns, exactly adapted, and closely concreted together in a parallel direction: every crack or accidental interstice having been filled up by a calcareous spathose matter with which the mass has been pervaded. By this examination it will be seen, that these angular columns vary much in their forms; some having only four, whilst others have five, six, or even seven sides: the pentagon being however the most predominant figure. With respect to their size, the difference is seldom considerable, they being generally about half an inch in diameter: some difference, however, arises from the irregularity of their forms, since one column, filling up the space between three or four others, will be found to be of perhaps double

* Silesiæ Subterraneæ. Cap. IV. § 47. P. 120. Tab. XVIII. Fig. 5.

the diameter in one direction that it possesses in another. By a moderate stroke against the side of one of these angular columns, one or more of them may be detached from the general mass. The sides of these columns will be found to be finely and closely striated longitudinally, the striæ being intersected by very fine and closely set transverse ridges. In those specimens in which the apices of the columns happen to be complete, they are concave, and have a prominent star, one-third of the diameter of the concavity, arising out of its centre.

A careful examination of the beautiful web-formed star, which is rendered visible in every column, by a transverse polished section, as well as the striated plumose appearance which is manifested by a longitudinal section, shews the internal structure of the stone, and of course the curious fabric of the madrepore from which it derived its origin. Numerous and exceedingly slender longitudinal lamellæ corresponding with the external striæ, are seen disposed perpendicularly from the circumference to the centre in a stellated form; which are intersected by proportionally numerous and equally delicate lamellæ, perpendicularly disposed nearly in concentric circles: other lamellæ, answering to the external transverse ridges passing horizontally through both sets of the perpendicular lamellæ. From the curious arrangement of these, and from their extreme minuteness and delicacy results that particular figure which has been by different authors so aptly compared with the texture of the spider's web. Mr. Da Costa, speaking of this fossil, says, " When polished, all these angular columns shew themselves on the surface, in a fine net-work of heptagonal, hexagonal, pentagonal, &c. meshes, and each mesh is adorned with a fine radiated star in it; and what with the beauty of the network and stars, and exquisite polish and fine surface it is capable of, it is as elegant a fossil as any of the fossil kingdom.*

* A Natural History of Fossils, by Emanuel Mendes Da Costa. Vol. I. P. 247.

The *lithostrotion*, according to Dr. Woodward, is all found on the rocky cliffs, about two miles from Tenby, towards Milford, in Pembrokeshire. But it is also found both on the river shores, and on the mountains in several other parts of Wales: and in Lancashire, Cheshire, Yorkshire, and in several other parts of England and Scotland. It is also found in different parts of Germany.

From the similitude of this fossil to a spider's web it might with propriety derive a name, had not a name, thus derived, been already applied to a coral of a different species. Perhaps the other epithet given to it by Volkmann would not be considered as very inapplicable; in which case it might be named *madrepora vorticalis*.

Da Costa, who distinguishes by the term *marmoroidæ* those stones which, although they have all the physical and chemical properties of marble, are not found in continued strata, but are only found in loose independent masses, lodged in strata of other substances, has named the stone which this coral has formed *marmoroides columnaris stellatus, lithostrotion dictus*.

One of the fossil corals which has been considered as belonging to this family, is the *lapis arachneolithi*, or spider-stone, respecting which the celebrated Bruckman wrote an ingenious disquisition in a letter to his friend, the learned Ritter.* From this it appears that stones, which, from their marks and form, bore a resemblance to the body of a spider, from which the head and legs had been removed, were frequently employed in some parts of Germany as a powerful charm for the cure of all kinds of hæmorrhages. These stones, according to the received vulgar opinion in those parts, were supposed to have been generated and voided by a spider. It was also imagined by the country people, that every spider, remarkable for its magnitude, contained one of these stones: to obtain the expulsion of which, the spider was to be enclosed

* Fr. Ernesti Bruckmanni, de Fabulosissimæ Originis Lapide ARACHNEOLITHO dicto Epistola. 1722.

in a glass vessel in which was also placed valerian or finely powdered sugar. Bruckman, however, shews that the spider-stone is nothing else but a petrified antediluvian coral, such as has been named the Indian *astroites*, and that the fabulous account of it has most probably been derived from its spots, which are not unlike those which are discoverable on the belly of the spider, and from its form, which frequently agrees with that of the body of a spider. This latter circumstance he, however, attributed to the cunning employment of art; and adds, that these stones generally far exceed in weight and size that of any spider or tarantula that is known, not excepting the celebrated enormous Brasilian spider named *nhamdù-guaca*. One of these specimens, which had been procured from Germany for the late John Strange, Esq. is depicted, Plate V. Fig. 7. It exactly agrees with the description of Bruckman: and upon examination with a lens appears to be part of a more than ordinarily minute *madrepora annularis*. It has been evidently fashioned into its present form by the tool of the artist. At *d* is given a magnified representation of one of the stars of this fossil.

LETTER IX.

MADREPORA STELLATA, &c.......M. TRUNCATA.......M. STELLARIS....... MADREPORITE FROM STEEPLE ASHTON... MADREPORA ORGANUM, &c.....M. FLEXUOSA......M. FASCICULARIS.......M. PECTINATA.......M. ARACHNOIDES....M. VERMICULARIS....CORALLOIDEA COLUMNARIA PENTAEDRA OF WOODWARD......MADREPORITE FROM INGLEBOROUGH....JUNCI LAPIDEI....KILKENNY MARBLE.

I HAVE had no opportunity of ascertaining whether *madrepora stellata*, *m. punctata*, *m. calycularis*, *m. nodularis*, *m. acropora*, or *m. cavernosa*, are known in a mineralized state.

Madrepora truncata, Plate V. Fig. 2, which is not at all, I believe, known in a recent state, is an exceedingly interesting fossil; not merely from its beautiful appearance, but from its curious mode of increase. It is a proliferous madrepore, and is formed of cyathiform bodies, possessing a superior stellated flat surface, with a concave central depression. From the flat surrounding surface of the stars, smaller stellated bodies proceed, possessing the same form and the same proliferous property.

The form of the star in this madrepore is remarkably elegant. It is composed of sometimes sixty lamellæ; thirty of which commence at the edge of the star, and proceed about half way towards the centre, when they descend perpendicularly, and then, at a certain depth, turn at a right angle, and converge to the centre of the disk; thus forming, in the centre of the star, a cylindrical cavity with a flat bottom. The other thirty of the lamellæ are shorter, and proceed only half way, that is, to the commencement of the central cavity. The termination of these at

this point, and the regular diminution of the thickness of the longer lamellæ until they have attained the central point, give a peculiar elegance of appearance to the star of this coral.

This fossil, which has I believe been only yet obtained from Sweden, is described and figured by Fougt,* who has also annexed the sketch, Plate V. *c*, which shews more plainly the mode in which the newly formed parts are attached to, and proceed from their respective bases. This is, however, very evident in the representation at Plate V. Fig. 2, in which the general characters of the fossil are well preserved. It is also figured by Bromel in Tab. 39 and 40, and by Volkmann in his *Silesia Subterranea*, Tab. XIX. Fig. 3, *a*, *b*. The fossil which is here represented, is calcareous, and appears to have formed part of a bluish lime-stone.

Madrepora stellaris, is a zoophyte, the examination of which is rendered very interesting by its curious mode of increase, which is similar, in a great measure, with that of the former madrepore, and with that which takes place in proliferous flowers. As the newly formed parts proceed, in the former instance, from the radiated disk, so here, from the centre of the stars, which are united at their margin, proceed single joints, which assume a similar form with the joints from which they proceeded, and possess, like them, the power of producing a similar joint from the centre of each of their disks. Each joint of this madrepore, like those of the preceding, bears somewhat of the form of a drinking glass ; becoming narrower downwards, but a little enlarged at its base : upwards it terminates in a wide, thin margin, marked externally with very numerous, faint, longitudinal striæ, intersected by transverse rugæ, so slight as hardly to be perceptible. The stars are flattish, and formed of numerous rays, generally about sixty, which proceed from the edge quite to the centre.

* Amœnit. Acad. Tom. I. Tab. IV. Fig. XI. 4.

From the centre of each star forming the upper part of the cup, proceeds another cup-formed coral, the lower part of which, as it increases, covers the lamellated superior surface of the lower coral, from which it has grown. Thus this coral proceeds in its growth, and as each of the joints enlarges, the inferior surfaces of the superior ones approximate the more to the edges of the inferior ones: and as this same process is, at the same time, carrying on upon numerous laterally contiguous stars, the size of the coral frequently becomes considerable, being sometimes as large as a man's head. Specimens of this size are frequently found on the shores of the isle of Gothland.

This fossil is described and figured in *Corallia Baltica*, Fig. XI. The medium thickness of each joint of which is there said to be about that of the little finger, and the length about the width of the thumb. A sketch from the above work, shewing the mode of growth of this madrepore, is given Plate V. *b*. At *a* in the same plate is a sketch shewing the mode of growth peculiar to *m. ananas*, represented at Fig. 1.

The madreporite, Plate VII. Fig. 11, is one which I was favoured with by that assiduous inquirer into subjects of natural history, William Cunnington, Esq. of Heytesbury, in Wiltshire, who obtained it from Steeple Ashton.

Its inferior side, which has the remains of its radical attachment, is very finely marked by minute longitudinal and transverse striæ, which, by crossing each other, give it somewhat of a finely reticulated appearance. The superior surface is stellated, being covered by stars closely set, and formed of raised undulating radii. The mode of increase peculiar to this corallite is curious and interesting. It appears, that when one area of its curious stellated fabric was completed, by the labour of its polypean inhabitants, another colony laid the foundation of another city on some part of the former surface ; and thus another and another colony laboured, until several areas were formed. Then, as the work proceeded, the nature of the structure became changed : the

labour of each colony seems to have been protracted, so that the perpendicular fibres were extended in a waving form, by which the fossil obtains somewhat of a foliaceous appearance, as appears from the sketch in outline, superadded to the above figure. This sketch, so illustrative of the mode in which the little animals extend their habitations, is taken from a drawing of the Rev. Joseph Townsend, being a faithful representation of the superior part of a specimen in his possession.

Madrepora organum formed by smooth cylindrical tubes about the size of wheat-straw, combined together at a little distance from each other by somewhat waving membranes, is figured in Fig .VI. No. 1, of *Corallia Baltica.* This coral is said to be found in a recent state in the Red Sea; but it is much more frequently found in a fossil state, chiefly on the shores of the Baltic.

Madrepora divergens is a fossil coral, much like to, and, perhaps, only a variety of, the coral just treated of; but of neither of these can I speak from my own observation.

Madrepora musicalis, described by Ellis* and by Borlase,† which is said to be formed chiefly in the Indian Ocean, and frequently thrown in large masses on the shores of Ireland, has not to my knowledge been seen in a fossil state.

Madrepora denticulata and *mad. rotulosa* are very unlikely to be detected in a fossil state, from the delicate structure of the elevated lamellæ at their edges being so very liable to injury, by the attrition to which substances which have become mineralized have generally been exposed.

Madrepora faveolata, I have reason to suppose, is sometimes seen in a mineralized state. But the specimen which I refer to this species, having been cut at both its upper and lower surfaces from a large specimen, I am unable to speak decidedly respecting it. Indeed in fossils of this genus, the cavities are generally so filled up as to prevent

* Philosophical Transactions. Vol. LIII. P. 432.

† Borlase's Cornwall. P. 241. Plate XXVII. Fig. 7.

the making out of such specific peculiarities as the reticulated surface of the sides of the stars.

Madrepora flexuosa is composed of striated, cylindrical, ramifying tubes, bending inwards, and then uniting: the stars being concave with lamellæ of similar lengths. In Ellis and Solander's Natural History of Zoophytes, Plate XXXI. Fig. 5 and 6, is a very correct figure of the recent coral, which very much resembles a beautiful fossil specimen, apparently of this species of coral obtained from Sweden. It is imbedded in a blue indurated marl; which, although possessing a considerable degree of hardness, has been partly removed by a careful employment of some instrument; by which the characteristic form and surface of the coral is fully displayed. The terminations, as has been already observed is frequently the case with the fossil corals, are not preserved. The coral is, however, thoroughly impregnated with a spathose substance, which on being polished shews the agreement of the stars with those of the recent coral, in being formed of lamellæ all of similar lengths, reaching from the circumference to the centre.

A fossil coral is frequently found in pretty large nodules, in St.Vincent's rock, near Bristol, a small specimen of which is depicted, Plate VI. Fig. 8, whose general external form approaches very nearly to that of the *madrepora flexuosa*. Its branches, like those of the *m. flexuosa*, are cylindrical, rough, and striated; but its stars, instead of being concave, are of a subglobose form: instead of being composed of radii of equal lengths, they are formed by a certain number of rays, which pass from the circumference to the centre, and by a similar number interposed between the former, and which are so short as not to reach above a fourth part of the length of the former. The number of these rays varies from twelve to upwards of thirty of each series, according to the size of the coral. These rays are intersected by perpendicular concentric circular lamellæ, which vary in number from two to six and more, according to the growth of the coral. A red ferruginous bole not only adheres to and deeply colours the external parts of these

nodules, but is evidently disposed between all the branches: and even the spathose matter which has filled the cavities of the coral has received a strong red tinge from the oxide of iron. A polished section of this stone manifests this, and shews that if it could be obtained in masses sufficiently large, it might, from the closeness of its texture, be employed for many useful purposes. It is indeed a marble of rather dull appearance; but it would not be without its beauties, since the little variety of colouring which it possesses is pleasingly disposed, and would be somewhat enlivened by the stellated spots yielded by the transverse sections of the coral.

Madrepora fascicularis, a figure of which is given in *Silesia Subterranea Volkmanni*. Tab. XVII. Fig. 14, is a fossil which possesses a very distinguishing character; the tubes of which it is formed almost always shewing, in their longitudinal section, numerous transverse septa, as may seen in the small specimen, Plate VI. Fig. 11. This peculiar appearance results from the following structure of this coral. It is formed of slightly diverging, cylindrical tubes, which are so closely beset by transverse septa, as scarcely to leave, sometimes, a space of the sixteenth of an inch between them. The stars of this madrepore are composed of about thirty radii or perpendicular lamellæ; half of which reach, from the circumference, to about one-third of the semidiameter from the centre, while the other scarcely extend one-third of the semidiameter from the circumference. Hence the centre of the tubes, for one-third of their diameter, are perfectly free from any perpendicular laminæ; in the next space of one-third, these perpendicular laminæ are but thinly placed; and it is only in the space next the sides of the tubes that these laminæ are fully disposed. In consequence of this arrangement it is obvious, that a perpendicular section, through nearly the centre of the coral, must in general display the transverse septa only; since in every longitudinal section they must be divided and exposed, whilst the longitudinal lamellæ must necessarily be partly concealed, even if the tubes are not filled with

spathose matter; and that from their standing back from the surface. If the tubes are filled with spathose matter, that must necessarily entirely conceal the longitudinal lamellæ, and leave only exposed, at the surface, the edges of the transverse septa, and of the columnal parietes of the coral. But if the section happen to be in a line with, and immediately upon, or directly through, any of the perpendicular lamellæ, such lamellæ then will indeed necessarily appear; but this circumstance rarely occurs.

Volkmann, in his account of this coral, which he has figured, describes it as *madrepora foraminosa minor, pseudo corallium album;* and particularly directs the attention to its interior transverse lamellæ. Dr. Woodward also mentions several specimens from different parts of England, the description of which *(coralloidea tubulosa crebris lamellis transversis intercepta)* exactly agrees with the fossil coral here described. The recent coral is said to exist in the Indian sea.

Madrepora pectinata, with rounded stars, having a radiated, extended, and tumid margin, is only known as a fossil. A specimen of this kind, found in Silesia, is figured and described by Volkmann, *(Silesia Subterranea*, P. 21, Tab. XIX. Fig. 2,) which exactly agrees with a specimen I obtained from the collection of Mr. Strange, a portion of which is figured Plate VI. Fig. 5.

So numerous are the fossil madrepores, especially those of this class, with aggregated, distinct, and separated stars, that to particularize them all would demand more room than this Work will admit, and would occasion more expense than their introduction would authorize. Many of those will therefore be omitted, whose characters cannot be clearly made out, or whose ambiguous appearances render it doubtful whether they may not be merely varieties of such species as are here described. Thus a fossil is figured by Bourguet as, *une millepore à grandes étoiles*,* a similar specimen with which I possess from the

* Traité des Petrifications, Tab. X. Fig. 46.

cabinet of Ingham Forster, Esq. but am unable to determine whether it is not the same fossil with the last described, differing only in the size of its stars.

Madrepora arachnoides, with close, smooth, and delicate stars, the rays of which are slightly waved. This fossil is figured with tolerable accuracy both by Scheuchzer* and by Volkmann.† It appears to be this fossil to which the remarks of Langius most properly apply, where he observes, " aliquando stellarum loco *rosas* exhibent, & tunc *rhoditæ, oder rosenstein*, vocantur; aliquando cometes, præ se ferunt & *cometitæ*, vel *cometstein* nuncupantur."‡ These remarks of Langius are employed in illustration of a fossil coral, represented Tab. XX. of the above work, and named by him, *astroites stellis maximis;* which figure has been selected by Gmelin, as illustrative of the *madrepora vermicularis*, but which is undoubtedly in more exact agreement with the coral which is the subject of our present examination.

In the specimen, Plate VI. Fig. 4, from Chatelor, the particular characters of this coral are observable. The slightly waving rays which proceed regularly from the centre, and are diffused over the flat surface, yield some faint resemblance to a flower; and from the elongation of these rays, as may be seen in the magnified star, Plate VI. Fig. 6, the idea has originated of their resemblance to the web of a spider, or to the streaming tail of a comet. From these different appearances, which are also very strongly marked on the two opposite sides of a specimen before me, have proceeded the names which this fossil has acquired of *rosenstein* and *cometstein*. A considerable tract of road from Bath, through Chippenham and Malmsbury, in Wiltshire, is kept up by a coarse, light, brown lime-stone, formed by this madrepore.

Madrepora vermicularis, the stars of which are formed of unequal, smooth, waved radii, several of which are bifurcated, is certainly much

* Lithographia Helvetica. Fig. 54. † Silesia Subterranea. Tab. XVIII. Fig. 11.

‡ Historia Lapidum Figuratorum Helvetiæ, &c. P. 60.

better represented by Fig. 11, Plate XVIII. of Volkmann's Silesia Subterranea, than by Fig. 4 of the same Plate, which has been selected by Gmelin for the illustration of this fossil. In that representation the peculiar bifurcated form of the perpendicular plates of the coral are easily discoverable; the figures of Volkmann, though coarsely executed, generally yielding a tolerable idea of the peculiar characters of the fossil presented to the eye.

It is evidently from this coral that the beautiful, light brown marble of Switzerland derives the pleasing figures with which it is enriched. Plate VI. Fig. 10, is a polished slice of this marble, in which may be traced a close agreement with the following description of it, as given by Da Costa.

" *Marmoroides fusco flavus stellatus*, s. *astroites fusco flavus*. This is of a dull, brownish, fleshy yellow colour; of a fine, glittering, compact, uniform texture; not heavy, and moderately hard. This kind is thick set with large stars, which generally are of the size of silver pennies. They are not tubes, but are composed of loose or naked thick longitudinal plates which are disposed from their centre to their circumference. These plates or rays are not equally produced from the centre of the stars, but are of very different lengths; nor are they regularly disposed in regard to their starry *radii*, for often two rays join at the centre and bifurcate at the extremities. The number of rays or plates to each star or coralloid body, also differs very much; some having twelve, others thirteen, and others all the intermediate numbers to twenty; but none have less than twelve. These plates are lodged quite perpendicularly with respect to the surfaces of the mass, and are not intersected, as in the madrepores in general, by any transverse septa or diaphragms. They are of a pale yellowish colour, and are composed of a coarse, glittering opaque spar. The whole mass is capable of a good surface though of but a middling polish; and notwithstanding the curious appearance of the stars, which are large and fine, yet on account of its dulness

of colour and indifferent polish, it is not a very beautiful stone. It is found in the island of Sardinia, as also in some parts of Switzerland.*

Madrepora undulata is formed of large elevated stars, with elongated bending rays. Like the former, this is found only in a mineralized state. Specimens of the same species in calcareous stone are frequently found in Sweden, Switzerland, and in England. The examination, with a lens, of a specimen of this kind from the neighbourhood of Bristol, manifests a considerable degree of similarity of structure between this coral and that of the *madrepora vermicularis*, the difference appearing chiefly to consist in the magnitude of the *m. undulata* exceeding that of *m. vermicularis*. In the specimen referred to, which is a soft calcareous stone, a few of the conical summits of the stars are broken, by which a transverse fracture of the coral is obtained, displaying a similar figure, on a smaller scale, with those displayed in the marble, Fig. 10.

Mons. Bertrand, speaking of those stones which had their surface marked with risings of stellated figures in relief, says, these stones are not as Scheuchzer, Volkmann, and all the authors who have spoken of them, have believed, corals themselves, but rather moulds or impressions of stellated corals made whilst the strata of which these stones are formed, were in a soft state.† But the fossil here figured places their existence beyond a doubt; since the projecting star is evidently the body of the coral, converted into a spathose substance.

The specimen figured Plate VI. Fig 12 and 13, bears a considerable resemblance, in the formation of its stars, with that of Plate VI. Fig. 10, but differs from it very considerably in other respects. The substance of the fossil which is here figured is a light reddish grey horn stone; but the colour varies a little in different specimens. In some it

* The Natural History of Fossils, by Emanuel Mendes Da Costa. P. 249.

† Dictionnaire Universel des Fossiles, par M. E. Bertrand. 1763.

is rendered much more beautiful by having a slight tinge of red; and in others, its appearance is pleasingly varied, by its having acquired a greater degree of transparency. In some specimens it passes from the light ashen-grey into a greyish black, and gaining at the same time a still more considerable degree of transparency, its transition into flint is completed.

It is obvious that the configurations with which the different surfaces of this fossil are adorned proceed from some coralline body; which, like the madrepore in the marble just described, is composed of stars closely ranged. The form of the stars, in this fossil, varies very much, so that it is not easy to discover two exactly similar: a disposition to the pentagon appears, however, to be most prevailing. This dissimilarity of figure and of arrangement is equally observable in the plates or rays of which the stars are formed. These plates originate nearly in the centre of each star, and by their several divisions and bifurcations fill up the polygonal area allotted to each star: the rays belonging to each star being in general disposed in six pencils or fasciculi, each bundle terminating in four rays or points. But it is so difficult to convey an idea, in words, of the manner in which the plates divaricate, as to render a reference to the representations of this fossil the more necessary. Plate VI. Fig. 12 and 13. By an examination of these, the similarity of the mode in which the separation of the plates takes place in this fossil and in the marble last figured may be perceived. It is necessary also to notice another agreement between these fossils. As in the madrepore from which the marble originated, the longitudinal plates are not intersected by any transverse septa, so it also appears that the madrepore, thus invested and impregnated with silicious matter is also without any tranverse intersections. But notwithstanding these agreements, the differences between these two fossils are, in other respects, such, as to plainly manifest that the madrepores of which they are constituted, differed materially. The stars of the coral in the Sardinian marble are not retained in distinct tubes; but

on the contrary the radii of one star are frequently seen to run into and connect with those of the adjoining stars; whereas, in the silicious specimen, the figures of the stars, though polygonal, possess a considerable degree of regularity, the consequence of being restricted by perpendicular lamellæ disposed in their interstices. These lamellæ are indeed not always discoverable; they are, however, frequently sufficiently so, to determine indisputably their existence. This is particularly the case on the reverse of the specimen: the stars may be there seen evidently circumscribed by the perpendicular lamellæ; and a net-like plexus may be seen proceeding from their sides in such a manner as to produce a stellated appearance, but totally different from that which is displayed on the other surface of the specimen. For the purpose of making this difference better understood, a representation of a part of this surface is given, Plate VI. Fig. 13, to allow of a comparison with the appearance of the upper surface at Fig. 12.

The ascertaining of the cause of this remarkable difference necessarily became highly desirable; but it was not until after the examination and comparison of various specimens that any reasonable conjecture could be formed respecting this curious difference. The first circumstance which seemed to lead to an elucidation, was the coexistence of the polygonal sides of the tube and of the reticular plexus; these being both evident on the inferior, and both disappearing on the upper part of the specimen. Farther examination made it also appear that a reddish brown colour, and a slight degree of transparency, existed in those parts of the superior surface corresponding with those parts which, on the inferior surface, were white and opaque. A considerable change, it was therefore evident, had taken place in the organized matter from which the stone had derived its characteristic configurations. The nature of this change was, after a little consideration, ascertained: the parts of the original coral, which still remained in the inferior part, had evidently been removed from

the superior part of the specimen. From observing this we are led to the following conjectures respecting the formation of this fossil:

The changes which it has undergone in the superior part appear to be of four kinds. 1. The abstraction of such of its constituent materials as were of an animal nature. 2. The filling of all, even its minutest interstices, with the finest and most impalpable argillaceous particles, which by hardening acquired the exact form of every cavity of the coral. 3. The removal, by some appropriate menstruum, of the calcareous remains of the coral, which formed the mould that had been thus filled. And, 4. The filling up of the void thus left, and the impregnation of the argillaceous cast with silicious matter.

The coral imbedded in an argillaceous matrix, would be secured from the introduction of any other extraneous matters besides those which the constant percolation of water through the mass might convey. The fine reticular internal structure of the coral would prevent the intrusion of coarse particles: those only which were held in solution, and those which were suspended in the fluid, in the finest degree of tenuity, would enter and be there detained. Thus, by a slow process, would all the internal cavities of the coral become filled, by the deposition of the argillaceous, and the crystallization of the impregnating silicious matter; whilst by the action of the water perpetually passing through the mass, almost the whole of the remaining animal principles would be removed. To give to this mass the properties possessed by the fossil whose formation is here endeavoured to be explained, no more seems to have been required than that the water which permeated it and passed through it should have held in solution a portion of silicious earth, by the influence of such a menstruum, as possessing a stronger degree of attraction for calcareous than for silicious earth, might, as it took up the former, deposit the latter in its place. But whether these supposititious processes be admitted or not; and whether the abstraction of the original calcareous matter and the

impregnation with silex, were simultaneous or took place at very remote periods, can perhaps only be determined by future observations: the fact is, however, indisputable, the original matter, of which the fabric of the animal was composed, has been removed, and its place supplied by silicious matter deposited from its solution in some appropriate menstruum.

For the farther illustration of this interesting fossil, I have caused various sections of it to be made, to admit of an examination of its parts in different positions and directions. By a longitudinal section, much of the real disposition of the plates composing the star is displayed, the continued perpendicular plates may be distinctly traced, the absence of any transverse septa may be ascertained, and that plumose appearance, which has sometimes procured for this fossil the appellation of *feather-stone*, may be plainly seen.

In Plate VIII. Fig. 39, of Bourguet's Traité des Petrifications, is a very close representation of the characteristic forms which this fossil assumes; although the figure is in other respects highly defective. In the description of the plates, which is throughout lamentably meagre, we only meet with *champignon étoilé* as the illustrative designation of the representation of this curious fossil.

This fossil is exceedingly common in the northern parts of Wiltshire: being turned up very frequently in the ploughed lands.

Dr. Woodward evidently refers to this particular corallite under the head of *Coralloidea columnaria pentaëdra;* and specifies it as *Coralloidea oblonga pentaëdra laminis à superficie ad axem tendentibus.* He describes a specimen, which he obtained from Wiltshire, as "A grey semi-pellucid flint, the ground much like the Indian agate, but thick set with white pentagonal columns, about a quarter of an inch in diameter. They are made up of several longitudinal thin plates, all set edgeways towards the axis. The columns stand parallel to one another: and are placed at equal distances, being about one-twentieth of an inch

from each other. The body being cut transversely, its whole surface appears like a net made up of pentagonal meshes, with a pentagonal star in each mesh. The sides of the columns are not exactly equal, and consequently not those of either the meshes or star."* Speaking of a plate cut off the above specimen, the Doctor remarks that it takes as good a polish as any agate, and is a wonderfully beautiful stone. In another specimen he remarks that the ends of the columns terminate in several stellar cavities, at the under surface of the flint, much like those in the larger astroites, or starred honeycomb stone: the hollows being filled on the other side with a flinty matter.

At Plate VI. Fig. 9, is represented a portion of a curious stone which I obtained from Gadsbridge, near Ingleborough. It is externally of a dark grey colour, and is chiefly composed, as the Figure shews, of coralloid bodies of a very peculiar form, somewhat approaching to the fusiform figure which though externally dark are internally composed of a light coloured spathose matter, and are imbedded in a fine lime-stone which is nearly as dark internally, as it is on the surface.

Examination of these bodies shews that they are externally deeply striated longitudinally. The striæ commence at one extremity of the body, and proceed to the centre, bifurcating as the body enlarges. These same striæ are then continued from the centre, and unite together as the body contracts in its dimensions. These longitudinal striæ are decussated by transverse ridges, which are only discoverable in certain points of view. As far as can be judged from the situation of such of these bodies as are least concealed by the matrix in which they are imbedded, there seems to be reason for supposing that they are connected together at their most central and enlarged

* An Attempt towards a Natural History of the Fossils of England, in a Catalogue of the Fossils in the Collection of J. Woodward, M.D. Vol. I. Part 1, Page 136, *e*, 41, &c.

parts. On one part of the specimen is represented the star which appears on a transverse section being made of one of these bodies. The perpendicular lamellæ, which correspond with the longitudinal external striæ, vary in number and length; but all proceed from the circumference towards the centre, and, as in the madreporean stars in general, are intersected by perpendicular lamellæ, disposed in concentric circles, and by others passing in a transverse direction.

It may not be amiss to observe in this place, that the numerous sections of fossil corals to which I have been under the necessity of having recourse, have shewn that the number of *radii* in the stars is a circumstance too variable to be employed as it has been by Mr. Ellis, Dr. Solander, and the illustrious Linnæus, to mark a specific difference. Thus in the coral now before us, the *radii* agreeing with the number of striæ observable externally, and the number of these depending on frequency of their divarication which must of course be according to the extent of the growth of the coral; the number of striæ must differ very much in the less grown coral, or in a section of its narrow part, from what would be found in the full grown coral, or in a section of its most enlarged part. The application of this observation to every madrepore which expands with its growth, must be sufficiently obvious.

This fossil has not, to my knowledge, been yet noticed by any author, neither do I discover that it has been known to exist in a recent state.

The fossil which is represented, Plate VI. Fig. 7, is particularly deserving of attention. It is composed of a coral in a mineralized state, imbedded in, and indeed helping to form, a dark coloured limestone, the interstitial part of which has evidently owed its origin to the disintegration of shells, corals, &c. and to the chemical recomposition of their particles.

The coral itself appears to have consisted of deeply striated and nearly cylindrical branches, which are, in general, about half an inch

in diameter. These from their frequent union have assumed other forms also, and particularly that approaching to an oval, resulting from the formation of one trunk, by the junction of two or three branches.

The superior termination of these branches appears from one or two, which have remained unchanged in their form, at one end of the specimen, to have been a concave star of a very elegant figure, formed by perpendicular plates converging from the circumference. The stars are also plainly seen on the polished surface of the specimen. It is there seen that the perpendicular plates, some much larger than the rest, reach in a straight line to the centre, and that in the triangular space between every two of these, are smaller plates which pass from the circumference in different lengths towards the centre. These smaller plates are decussated by other perpendicular plates concentrically disposed, and thereby forming a species of net-work within each small triangular cavity. This structure, not exactly indeed expressed in the engraving, gives to the stars a peculiar richness of appearance, which is still farther increased by the alternately greater and less projection of the ends of the straight plates beyond the periphery of the circle formed by the most external of the concentric plates.

The fossil madrepores, with distinct, finely striated branches, terminating with the madreporean star, have been considered by the earlier oryctologists as petrified reeds, *(junci lapidei)*. Thus Mercatus gives the representation of a madreporite of this kind under the designation of *juncus lapideus;* but Lancisius remarks that this stony reed of Mercatus differs very little from *millepora Imperati.*

Madreporites bearing this reedy appearance are found in several parts of this island. They are frequently met with in Derbyshire, of two inches in thickness, and upwards of two feet in length.

A small specimen of this kind of fossil madrepore from Derbyshire, of rather a conical form, is figured at Plate VI. Fig. 2. Sufficient of the

internal structure is shewn to illustrate the figures which proceed from this kind of coral, in several of the marbles, found in different parts of the British empire.

In a fragment of a madreporite of this kind, of a large size, being two inches in diameter, from Coalbrook Dale, the external surface is so marked by longitudinal striæ and transverse ridges, as to give it very much the resemblance of a jointed reed: and it is so filled with lapideous matter as not only to have obtained the compactness and weight of stone; but to have had nearly all its interstices filled up, and its characteristic star obliterated. Its substance appears to be penetrated also with bitumen, some of which still remains on its surface, and is sufficiently soft to receive easily a mark from the pressure of the finger.

Plate VI. Fig. 3, represents a specimen of marble, nearly formed of a small corallite of this class. This marble, which I lament the not being able to determine where it was obtained, is of a brownish red colour; being much darker in its interstitial parts than in the corallites themselves, and is susceptible of a good polish.

The madrepore which has entered into the formation of this marble, appears to have been of the smaller species; the branches being about the size of a goose-quill. From the cutting of the marble, various sections of the madrepore, in different directions are obtained, by which its internal structure is rendered very evident. In the transverse sections, the radii formed by the perpendicular lamellæ or plates are seen uniting in the centre, and making the madreporean star. In some of the longitudinal sections; in those, in which the coral has been divided, immediately upon one of these longitudinal plates, a plain unfigured substance appears, the same as when the division is near to the external or conical surface of the coral; but in those, in which the section has been made between these plates, there the sections of the horizontal plates are seen intersecting the perpendicular ones.

The diffusion of the red colour through this specimen requires some little attention. It extends through every part of the mass, and appears to have percolated through the external part of the coral into its internal substance; in such a manner that no gross substance has entered; the colouring matter appearing to have been here deposited from its solution. That the colour has not been derived from the coral itself, may safely be inferred: there appear, therefore, to be two modes by which this colour may have been yielded. Either the decomposed coral might have been imbedded in a matrix, of which the oxide of iron formed a part, and which, by the access of a fit menstruum, became capable of penetrating through every part of the coral: or both the coral and the surrounding matrix might derive their colour from the influx of the coloured fluid derived from some other source. In either case, it appears evident that this diffusion of the colouring matter, and its introduction into the mass, were previous to the perfecting of the lapidifying process.

On subjecting this marble to the action of diluted nitrous acid, its decomposition took place very speedily. A considerable quantity of carbonic acid gas was separated, the calcareous part was dissolved, and a red substance, an oxide of iron, gradually sank to the bottom. Whilst the decomposition was proceeding, a substance was detected, whose presence, at least in so obvious a state, was not expected. As the separation of the other parts took place, ragged, flocculent pieces of apparently a membranous substance were left, adhering to those parts where the coralline substance had been observable. These, on the least agitation of the fluid, were seen to wave to and fro, and on the motion being increased fell off, and soon reached the bottom of the vessel from the weight of the solid matters which were attached to them.

In the specimen of marble figured at Plate VI. Fig. 1, from Kilkenny, the remains of a coral of this kind, but of a larger species, are very evident. The ground of the marble is of a deep black, but the part of the marble possessed by the coral is of a very light grey.

In fineness of grain and in susceptibility of polish it appears to equal any marble. From this circumstance, and from the considerable difference in the colour of the madrepore and of its matrix, the structure of the former becomes very conspicuous, and the astonishing labours of its original inhabitant are very easily traced. In one part, the converging perpendicular plates, displayed by a horizontal section of the madrepore, are discovered; whilst, in another part, a longitudinal section has not only shewn numerous horizontal plates; but also yields a fair view of the beautiful reticular texture of the coral, resulting from the frequent intersections of the perpendicular by the transverse lamellæ.

The very considerable difference of colour in the ground of this marble and in the animal part is particularly deserving of attention. As in the former specimen the regular diffusion of colour through the whole mass appeared to authorize the conjecture that the colouring matter was introduced previous to the coral having undergone its lapideous change; so here, the exclusion of the blackening particles from the coralline part of the marble seems to warrant the supposition that the coral had acquired a stony impregnation previously to its having become imbedded in the including mass of calcareous matter. Thus two distinct lapidific processes, occurring, perhaps, at the distance of many ages, may have been employed in forming the marble of which we are now treating. Any difficulties which appear to be in the way of this supposition will diminish, when it is considered, that in several marbles, indeed in all the *breccia* marbles, this two-fold lapideous impregnation must necessarily be admitted. These are composed of fragments of various marbles, which, after having been formed in perfect strata, have been broken into small pieces, and have then become agglutinated into a compact mass, by the medium of a fluid, which, from its saturation with the carbonate of lime, has possessed the required lapidific power, and which it has exerted during its interposition between these detached fragments.

A piece of this marble was suspended in a glass vessel, containing

diluted muriatic acid, and was speedily dissolved, with effervescence. During the decomposition of this piece of marble, not the smallest filament of membranaceous substance became detached; but, on the contrary, the newly-forming surface was as perfectly clean and smooth as if it had been a piece of primitive lime-stone: the black matter from which the marble derived its colour falling to the bottom of the vessel, during the solution of the marble. This powder being dried was projected on melted nitre and immediately produced deflagration: a circumstance which, with the form of the coral having been visible in the marble, shews the curious fact that a part of the colouring matter of the marble was an animal charcoal.

In this class of fossils may be also placed the madreporite, Plate V. Fig. 5, from Steeple Ashton, which was presented to me by Mr. Herbert, of Bristol, whose kindness I have before had occasion to acknowledge. The perpendicular lamellæ forming the star of this madreporite, the periphery of which is not always circular, are connected, not only by short and partially disposed transverse plates, but by several series of larger horizontal plates, passing at the distance of a quarter or of half an inch, through the whole substance of the madrepore, and connecting the perpendicular lamellæ so firmly, as to give the appearance, in several parts, as if the perpendicular plates had been tied together by a tight ligature. Its form of ramification somewhat resembles that of the *madrepora carduus* of Ellis; but it does not appear that its surface was muricated, or that the terminations of the lamellæ were serrated, as is the case in that madrepore. Nor does there, indeed, appear to be any close resemblance between this fossil and any madrepore which has fallen under my examination. It appears to have been imbedded in a hard, close-grained lime-stone, of a pale yellowish colour, part of which, containing fragments of shells, and other marine remains, still adheres to the madreporite. The madreporite itself is formed of a spathose substance, strongly impregnated with iron; as is the case with all the fossil madrepores found at Steeple Ashton.

LETTER X.

MYCETITÆ OF WOODWARD......PORPITAL AND TURBINATED COMPOUND MADREPORITES......RAMOSE MADREPORITES......MILLEPORITES......CELLEPORITES, &C.......FOSSIL CORALS OF UNKNOWN GENERA.

The bodies whose nature we shall next inquire into, have frequently engaged the attention of oryctologists, in consequence, not only of their being creatures of a former world, but of the great variety of appearances which they yield, and the considerable differences which exist between them and any of the recent coral bodies at present known.

This class of bodies does not appear to have been hitherto examined with that attention which they seem to merit. Dr. Woodward, who has investigated their structure more carefully than any one else, distinguishes them as *mycetitæ coralloides*, and divides them into *mycetitæ conoides, seu calyciformes*, and *mycetitæ forma compressa, seu discoides*. But, guided only by their conoidal or discoidal form, he blends the simple madreporite, the porpital, and turbinated, each containing one star, already examined, (Page 23,) with those of this class, which are composed of several stars; and which, not having been yet separated from those other bodies of a somewhat similar form, but of a totally different structure, I shall take the liberty to distinguish as porpital and turbinated compound madreporites.

The first of these (the porpital) is of a discoidal form; it has a superior, slightly convex, stellated surface; and an inferior surface, which is generally concave, and finely marked by radiating striæ and

concentric rugæ, disposed round a pedicle. The substance is generally spathose.

The structure of these bodies materially differs from that of any of the fossil madrepores we have yet examined, as will be shewn by the annexed figures. Plate VII. Fig. 4, represents the inferior surface, in the centre of which is the pedicle, surrounded by alternate risings and depressions. With this surface, the little artists appear to have commenced their labours: this being the basis on which has been disposed a curious plexus of tubuli investing tubes placed at regular distances, whose edges are internally crenulated; which latter circumstance is however only discoverable by the aid of a lens. Thus aided, the eye discovers that the superior surface, Fig. 5, is generally beset with very minute openings, which, occurring on the edge of larger openings, occasion their edges to assume a crenulated, stellular form. The section, Fig. 2, shews the tubes, originating at the inferior surface, divided into separate chambers by tranverse lamellæ, and thus proceeding to the superior surface. These fossils are found in Gloucestershire, Staffordshire, and in many parts of England.

At Plate VII. Fig. 3, is the representation of the under surface of a very curious fossil coral from Dudley, in Staffordshire, which may be considered as a variety of this species. The difference chiefly consists in the diverging striæ, on the under part, being considerably larger and more distinct; and in the cavities, on the superior surface, being polygonal, and forming a honey-comb surface, as represented in outline at Fig. 7.

Plate VII. Fig. 10, is a specimen of the compound turbinated madrepore. This, like the former, is composed of crenulated tubes, surrounded by a plexus of tubuli, which open on the general superior surface, and which, by the regular arrangement of their terminations round the openings of the tubes, gives to them a stellated form. In this fossil the labours of the polypes have commenced at the pedicle, and one area having been completed, another has been formed over

that, of a more extended surface: and thus, by a continuance of these labours, on an increasing scale, the turbinated form has been produced.

This madrepore, like the former, passes into several varieties, depending on the direction given to the tubuli by different circumstances. Thus in the fossil here depicted, a conoid form is produced by the labours of the madroperean insect having been directed in a more perpendicular direction than in the former coral. Traces of this species of coral is sometimes detected in silicious pebbles: yielding an additional proof of the great antiquity of their formation.

A corallite of the discoid kind was suspended in muriatic acid much diluted, which, by removing the calcareous earth, soon exposed the flocculent membranes of the madrepore. But, in this instance, the membranous flocculæ were exceedingly small, hanging but a very little way below the edge of the coral; and, on the least agitation of the glass, innumerable minute portions of membranes became detached, and slowly sank to the bottom of the glass. The smallness of the pieces of membrane might be here probably accounted for, by the structure of the madreporite which they composed; since being of the species delineated, Fig. 4 and 5, it must be obvious, that, from the multitude of pores with which it is pierced, the membrane must suffer such frequent inflection as would give very little reason to expect that, in a corroded preparation, of even the recent madrepore, any thing like the form of the madrepore could be preserved. The circumstance of these membranous flocculi appearing to possess a greater degree of gravity than belongs to animal membrane in general, may be accounted for, by considering that they may yet retain some particles of earth in some of their cavities, which are defended from the action of the acid, by being completely inclosed in the membrane.

The ramose madrepores, with distinct stars and tubercular porous interstices next require our notice. Of these, it will not be possible to exhibit many interesting specimens, in a mineralized state; since, from the small number of specimens which have been found, and

from the injuries which they have sustained, but little information can be acquired respecting them. The characters by which this would be determined are chiefly, the form of their ramifications, and the form and disposition of the small stellular pores with which they are beset. But the fracture of the branches, and the obliteration of the pores, are among the most frequent injuries which these bodies have sustained: hence the ascertaining of their species, a circumstance particularly desirable, can but seldom be accomplished.

The specimen figured at Plate VIII. Fig. 9, which is from Mr. Strange's Collection, and was obtained from France by that gentleman, is a madrepore imbedded in a very hard chalk. The fragment is too small to allow any determination with respect to its species.

The madrepore represented at Plate VIII. Fig. 6, is from the Collection of the same gentleman, and appears to have been obtained, with many other similar fragments, from Switzerland. The surface is pretty thickly beset with cavities, shallowly, but rather extensively, stellated.

Of the millepores, at least from the few which I possess, or have had the opportunity of seeing, I suspect, that not many are found in a mineral state.

The ramose millepore, from Wiltshire, Plate VIII. Fig. 3, is in a tolerable state of preservation: its pores are very distinctly seen by the aid of a slight magnifier, as at Fig. 11. It is imbedded in a very hard and close lime-stone of a brown colour.

Of the genus Cellepora I am unable to speak decidedly. In the masses of calcareous stone of St. Peter's Mount, at Maestricht, are some fossil substances which seem to belong to this genus, and a minute coralline substance resembling cellepora pumilosa is frequently seen on some of the fragments of encrinites, in the neighbourhood of Bath.

The genus Isis, the generic characters of which are, the possessing a stony articulated stem, the joints longitudinally striated, connected

by a spongy or horny substance, and covered with a softer porous and cellular flesh, does not present to our observation many fossils.

One species, and that, as far as acute inquiry has gone, a species unknown in a recent state, alone demands our examination. This fossil is depicted, Plate VIII. Fig. 2, 4, and 7, from specimens which Mr. Strange obtained from Sicily. Augustine Scilla called the attention of the learned to this fossil, in his interesting work *La Vana Speculazione Disingannata dal Senso*, which afterwards appeared in a more condensed form in a Latin edition, published at Rome, and intituled *De Corporibus Marinis Lapidiscentibus quæ defossa reperiuntur*. Scilla relates that, at one time, he was disposed to attribute the origin of these fossils to the leg bones of some animals; but, having discovered this error, he states it to be his corrected opinion, confirmed by some well preserved specimens, that these substances are the fragments of some jointed coral, bearing a strong resemblance to the knotted coral described by Imperatus.* The coral of Imperatus, he observes, was found in the sea near to the Island of Majorca; whilst the corals he describes were found in the Calabrian mountains, but of their origin, as well as whence they were brought to this island, he remarks, we are entirely ignorant.

This fossil is now a compact foliated calcareous stone, of a long, slender, and cylindrical form, expanding at each end in an articular body, the ends of which, in some specimens, rise suddenly in a pyramidal process, which is generally a little to one side of the centre of the surface; and in others, the ends are formed into such depressions as would seem to accord with the risings just described. Even the naked eye discovers very fine striæ, which pass longitudinally over these bodies, entirely to the edge of their enlarged terminations, on the face of which circular striæ may be also seen: and in those specimens which have suffered some degree of disintegration, it will be

* Imp. Hist. Nat. Libr. 27.

plainly seen that these bodies are formed of fine, and very closely united concentric lamellæ.

Most of the circumstances here mentioned may be noticed in Fig. 4, whilst from Fig. 2, some notion may be gained of the form, which the coral would assume by its ramification. Fig. 7 represents a small calcareous mass, from the Siculean mountains, formed chiefly of the fragments of this coral. Remains of this species of fossil are also found at Calne, in Wiltshire, in a light yellow coloured lime-stone.

It is only possible to form very vague conjectures respecting the form which this coral originally bore, and the recent species which it might have the nearest resembled; since, by having been deprived of the soft porous and cellular flesh with which it was invested, and which was the habitation of the polype (hydra) peculiar to it, its form must have been exceedingly changed. From the great plenty in which this fossil has been found in Sicily and other parts, there is every reason for supposing the coral, from which it derived its origin, must have existed in considerable quantity.

I do not know that the remains of any individual of the genus ANTIPATHES have been discovered in a mineralized state. Nor do I know of any species of the GORGONIA, similar to any now existing, having been found, that had suffered that change.

In the Dudley lime-stone, and in the lime-stone of St. Peter's Mountain, is a vast variety of minute, indeed of almost microscopic substances, which very much resemble some of the reticulated gorgoniæ; but which perhaps would with more propriety, be considered as corallines. But to illustrate the nature of these substances would require so many additional engravings as puts me under the necessity of deferring their investigation.

We now arrive at a series of specimens, which bear so little analogy with either the recent or fossil corals, that it appeared to be exceedingly difficult to determine in what part of this Work they should find a place. Indeed, so slight is the circumstance which has

led to their admission among the corals, and so essentially different are these specimens from any zoophyte with which I am acquainted, that it appears to be of very little consequence where they are, at present, introduced, so long as they are permitted to form a distinct genus. To this distinction they seem to be fully entitled, since their globular form alone separates them from all other genera. The fossils of this species, or genus, may be described as *silicious or calcareous masses of small bodies, of a compressed globular form, connected by minute fibrillæ or tubuli.*

The calcareous stone, Plate VIII. Fig. 1, appears, on a superficial view, from its being composed of small globular bodies, about the size of a poppy-seed, to resemble those stones which, from their fancied likeness to the eggs of fishes, or to certain seeds, have obtained the names of *oolithi cenchrites*, *meconites*, &c. but the eye, aided by a lens, soon discovers a material difference. A section of those stones being made it is found, that the little round bodies of which they are composed, possess a laminated structure; from which those who have possessed a warm imagination, have been led to fancy that they could perceive the yolk contained within the albuminous part, and the latter surrounded by a shell. But in the stone now under examination, and which is formed of a white calcareous matter, not bearing a spathose appearance, the little roundish bodies, which are imbedded in a matrix of a similar substance with themselves, have evidently a more compressed form than the bodies just spoken of, and in the centre of their superior part, in a little depression, a small prominence, like the commencement of a minute process, may be seen.

It is true that this peculiarity of structure is not discoverable in all these little bodies: on the contrary, by far the greater part of them, having been worn down by weathering or bowldering, display their internal structure only; but of this no more can be said than that it manifests no appearance of lamination. The peculiar structure observable on those which have not sustained any injury seems decidedly

to prove their animal nature. By the aid of a lens, of moderate power, the central depression and projection are very plainly seen: and the eye, thus assisted, also discovers numerous thread-like processes, by which these bodies are laterally connected. This curious conformation of these substances is still more distinctly observable, on the inferior surface of this stone, which displays its fracture; it having been evidently here separated by violence from the mass to which it originally belonged.

At Plate VIII. Fig. 12, is a magnified representation of five of these bodies, by which the frequent connexion effected by means of these filamentary processes will be distinctly seen. The bodies which are here figured are connected by lateral filaments; but from the marks which remain of attachment of similar filaments, on their superior surfaces, it is highly probable that these bodies were connected by filaments, proceeding from several parts of their surface. Such an arrangement of parts seems decidedly to determine that these bodies are not, as might be supposed, merely calcareous concretions; but that they have indubitably derived their existence from the regular operation of the laws of animal organization.

The silicious pebble, Plate VIII. Fig. 10, which was found in the Gravel-pits, near Hackney, had long been the subject of fruitless conjecture: no circumstance being discoverable in its appearance which would determine its place in any classification, nor any analogous body being recollected by which its nature could be illustrated. By its comparison with the preceding specimen, its analogy with it appears to be indisputable. The whole fossil being of a calcedonic substance, possesses that degree of hardness which has rendered it but little susceptible of injury from mechanical violence; and hence its peculiarity of structure is still distinctly observable.

In this specimen, as well as in another, from the Leverian Collection, the character of the original substance is plainly discoverable. Small round compressed bodies, not exceeding an eighth of an inch

in their longest diameters, and horizontally disposed, are connected by processes nearly of the fineness of a hair, which pass from different parts of each of these bodies, and are attached to the surrounding ones; the whole of these bodies being thus held in connexion.

That the formation of these bodies has been the work of some animal, of a nature similar to the polypes, by which the known zoophytes are formed, cannot, I think, be doubted. But in what genus in the order of zoophtes can they be admitted?

The specimen figured Plate VIII. Fig. 8, is a silicious pebble from the Gravel-pits, at Hackney, bearing sufficient characteristic marks to shew that it may, with propriety, be classed with the specimens which have been just described. A similarity of character is seen in the slender processes by which the different parts of the coral are connected together: but the similarity, in this respect, seems to point out only its being of the same genus, whilst the want of rotundity in its more solid parts, warrants the supposition that it is of a different species.

What the real difference is between these several specimens does not, indeed, seem likely to be ascertained, until, by additional observations on other specimens, which are still farther illustrative, more particulars can be obtained respecting this curious fossil, whose recent analogue has not, I believe, been yet found.

The silicious stone, represented Plate VIII. Fig. 14, is from Mr. Strange's Collection, but whence obtained is not known. It is composed of roundish bodies of different sizes; the largest, however, not exceeding a quarter of an inch in diameter. These, by their section, are shewn to have possessed a certain round hollow, and to have had their more solid surrounding part formed of a substance, which, being now cut through, appears similar to the petals of a flower. What was the original state of this substance is not easy to conceive; but from the striæ which pass from its periphery to the central cavity, it appears

to have been formed of detached parts, perhaps tubules, which have originated on the borders of the central cavity and have radiated regularly round it. Fig. 13 is a magnified representation of a section of one of the round bodies, by which the above description will be better understood. That these substances did not originally exist in a silicious state may be inferred from the appearance observable in a few of the striated parts, denoting their having suffered a degree of flexion: a circumstance which could not have occurred if they had been in a hard and rigid state.

To what kind of substance this stone is indebted for its origin, is not possible perhaps at present to say. It is admitted in this place, in consequence of the resemblance it bears in some respects to the preceding specimens; and with the hope that information respecting it may be obtained, from the remarks made on some more illustrative specimen.

Some of the extraordinary circumstances which have arrested our attention, whilst examining into the nature of fossil corals, now demand a few general remarks. You cannot but have observed how completely I was foiled, in my attempt to preserve a parallel between the fossil corals which I have particularized, and the several corals which are enumerated in the *Systema Naturæ* of Linnæus. Indeed, so little could this parallel be preserved, so little agreement could be traced between the recent and the fossil corals, that I find myself under the necessity of acknowledging that I am not certain of the existence of the recent analogue of any really mineralized coral.

This dissimilarity between the creatures of this and the creatures of the former world is a circumstance which appears to be so inexplicable, that I can only admit it, without attempting to account for it. It however furnishes us, I think, with a strong argument against that theory, which supposes the changes which this planet has undergone are all attributable to the constant, regular, and gradual processes of nature,

which have been acting from an indefinite period of time, aided by the occasional heavings of strata, effected by subterraneous heat. By this system—by the gradual interchange of situation between land and water, we might account for the mountains of fossil coral which are found at considerable distances from the sea, were it not that so little agreement is observable between the fossil and the recent coral. Had the coral of the mountain and the coral of the sea been constantly the same, it would, indeed, have furnished a powerful evidence of the gradual change of relative place in the strata, which were once covered by the ocean, but which are now thousands of feet above its surface: the gradual receding of the sea would have sufficed for the explanation.

But how, according to this theory, shall we explain the disagreement between the coral of the mountain and the coral of the sea? I see no explanation which can be thus obtained: every thing being supposed to have proceeded in its regular course, the animals of the first creation must then have exactly resembled those of the present hour. Some vast change, of powerful and even universal influence, must be sought for, to explain this wonderful circumstance: and such, doubtless, can only be found in the destruction of a former world. Thus, indeed, we shall be enabled to account for the existence of various animals, in a mineral state, whose analogues are unknown; but it must be admitted, that even this circumstance is not sufficient to account for the existence of animals at the present period, of which no traces can be found in the ruins of that former world.

LETTER XI.

FOSSIL ALCYONIA......CONSIDERED AS FRUITS BY VOLKMANN AND SCHEUCHZER......FOSSIL ALCYONIA OF FRANCE.....DIFFICULTIES IN DISTINGUISHING THE FOSSIL SPONGES FROM FOSSIL ALCYONIA... VARIOUS SPECIMENS DESCRIBED.

We now arrive at the examination of that class of bodies, of which it was remarked, in the former volume, that although they were decidedly animal substances of marine origin, yet, from the resemblance which they bore to terrestrial fruits, their animal origin had been doubted, and they had been considered as petrified oranges, figs, funguses, nutmegs, &c.

There is no substance which has attracted our attention, during the prosecution of these inquiries, which can yield so many subjects for investigation as these bodies. For, whether we consider the peculiar forms with which they are endowed, the original modes of their existence, or the extraordinary changes which they have undergone, a variety of subjects of inquiry, of the most curious nature, will necessarily arise.

That many terrestrial fruits and seed vessels, containing the ligneous matter, have been found in a petrified state, has been already shewn: of these, of course, it is not intended here to speak. But substances have been repeatedly met with, the general appearances of which have so much accorded with those of some terrestrial fruits, as to have led several learned and ingenious men to place them among these substances. Thus Volkmann was deceived, and figured and described

one of these bodies as *nux moschcata fructu rotundo.* Casp. Bauhin.* Scheuchzer, on the authority of Volkmann, adopted the same figure and description. Nor will this error be considered as without excuse, when the great resemblance of many of these substances to terrestrial fruits is shewn. Indeed, I much suspect that, after all the circumstances have been examined, some persons will be found who will not be readily disposed to consider substances, bearing such appearances, as subjects of the animal kingdom. The propriety however of doing this will perhaps appear, when other bodies will be shewn passing, through almost insensible gradations, from these bodies, which so closely approximate, in their general appearances, to the subjects of the vegetable kingdom, up to others, whose characters are sufficiently marked, to leave no doubt whatever in the mind as to their animal origin.

No one I believe has been more industrious, or more successful in their inquiries, respecting these bodies than M. Guettard, as appears by his very ingenious Essay, *Sur quelques Corps Fossiles peu connus*, in the Memoirs of the Academy of Sciences at Paris for the Year 1757. M. Guettard observes that, at Verest, near Tours and Saumur, and at Montrichard, in Touraine, there are found, at some depth in the earth, numerous bodies, which, from their very close resemblance, in figure, to figs, pears, oranges, and other fruits, are there considered as fruits, which, having fallen from their trees, have been buried in the earth, where they have undergone the process of petrifaction. These bodies, it appears, not only differ very much from each other, in their forms, but also in their structure: and in Mons. Guettard's judgement are divisible into two kinds; those which possess somewhat of a globular form, and those which are conical or funnel-formed.

The former, he observes, may be divided into the body or globular part, and the pedicle or elongated part. In the centre of the

* Silesiæ Subterraneæ. Tab. XXII. Fig. 6.

superior part of the body is a circular opening, which, in some of the specimens, is closed by extraneous matter, derived from the matrix in which they laid. This opening, which is larger in its upper part than it is downwards, is continued almost to the pedicle, and in some specimens appears even to penetrate it. This is however very difficultly ascertained, since the opening is in general loaded with the extraneous matter. From the circumference of this opening lines may be traced, which not only pass over the whole of the spherical part, and inosculating, are continued to the elongated part, where they form striæ more or less plain; but they are also found to penetrate into the substance, both of the body and of the pedicle. These bodies have, in general, but one of these openings, but some have more; and Mons. Guettard found one with three distinct openings. In this specimen, the lines or striæ just mentioned were seen to collect around the circumference of each of the openings and, after inosculating, to pass into the pedicle, in nearly the same manner as in the others.

A great disproportion, it appears, is frequently observable between the size of the globular part of these bodies and their pedicle; sometimes the pedicle appearing very large, and sometimes very small, in proportion to the body; this difference is, however, frequently the consequence of the pedicle having been broken off; a circumstance which indeed so often occurs, that a perfect specimen is very rarely to be met with: numerous fragments of the pedicles being dispersed about in the places where these bodies are found. The pedicles are in general of a conical form, and not unfrequently flattened.

By grinding the globular part, as well as the pedicle on a stone, he discovered that their texture appeared to be similar, and that by the frequent ramifications of the fibres, of which their substance was composed, a net-work was formed, not much unlike the parenchyma of vegetables. We therefore perceive that a loose resemblance, sufficient to excuse the vulgar opinion of their origin, is observable between these bodies and the terrestrial fruits. These bodies, like fruits, appear to

have been formed chiefly of a parenchymatous substance; their pedicle seems to answer to the stalk; whilst the opening on their superior part agrees with what is termed the eye of fruits. But a little attention shews that, unlike to the parenchyma of fruits, which is formed of vessels terminating in minute points, the substance of these bodies is formed of a species of net-work, which, as M. Guettard observes, if all the matter contained within the meshes could be removed, would resemble a skein of thread, of which one part, answering to the pedicle, is pinched together, and the other, answering to the body, is spread out without being cut. Again, the eye, in fruits, is not pervious, as is that part which answers to it in these fossils; nor does the pedicle at all agree with the stalk of fruits, either in proportionate size, or in figure.

Scheuchzer describing a fossil of this kind refers it to the *Alcyonium stupposum Imperati*;* but of the identity of these substances Mons. Guettard, with much propriety, doubts; although he allows that the external form, and particularly the opening in the upper part, might readily lead to this supposition. This doubt arose in the mind of M. Guettard, from comparing the structure of one of the Alcyonium stupposum of Imperatus with the description of its structure as given by John Bauhin and by Count Marsilli; the result of his comparison being, that both the descriptions were in some respects erroneous. Taught by careful examination, he states it to be composed of fibres, more or less fine, intersecting each other, without order or regularity, and anastomosing together by their ramifications, by which they form irregular meshes of various figures and quite empty. By this contexture a spongy mass is formed, which is covered by a thin pellicle, constituted in the same manner, excepting that the texture is more close and compact, and extended into a membrane-like substance, which may be detached and easily raised from the body, and which, when examined by

* Lithograph. Helvet. P. 15.

a lens, appears to be a mass of fine fibres forming very small meshes, similar to the large ones of which the body is composed. The foot stalk, which spreads out and is a species of basement by which the fig is attached to the body on which it grows, does not seem to differ from the general substance in its conformation. Hence M. Guettard concludes the sea-fig to be merely a sponge, differing from other sponges only in form, and possessing like them the property of imbibing water and losing it by compression.

On comparing the structure of the sea-figs with that of these fossils, M. Guettard points out differences which are undoubtedly very essential. In the pedicles of the fossils, he observes that circular points may be seen, which will be found to be continued into the spherical part of these bodies; so that by different transverse sections they may be traced, passing on like so many vessels, from the pedicle into the substance, and even on to the surface of the fossil: whereas, in the sea-fig, the fibres have no such regularity of disposition, nor are they thus continued like tubes from the pedicle, into the substance of the fig.

M. Guettard next describes the other kind of fossil, which belongs to the class of fungites, and which, like the ficoid fossils just treated of, are open at their superior and wider part, and in general possess somewhat of a conical form: and from their varying in length, width, and size, frequently bear a resemblance to cups, glasses, funnels, cones, &c. whilst others are longer, cylindrical, and even fusiform. This variety of figure is frequently dependant on the circumstances of the fractures which they have suffered; these fossils, like the former, being rarely found in a perfect state. M. Guettard appears to have been entirely foiled in the attempt to discover any recent zoophyte which might be considered as bearing any analogy with these fossils. He first was disposed to consider them as being similar to the *spongia elegans* of Clusius, or the *spongia dura* of Sloane, but this opinion he found reason to relinquish, and was then induced to believe that they

bore a nearer resemblance, in their general characters, to some species of madrepores than to any of the sponges. In several of these fossils he discovered an outer layer, which appeared to differ from the general substance of the fossil; and his opinion, he thought, derived support from this circumstance, for, on examining the interior lamina of these fossils, he conceived that it much resembled the hard smooth part which forms the corresponding parts, in madrepores, &c. Madrepores and corals, he observes, are covered by a substance which has been distinguished as their cortical part, and immediately beneath this, there is a smooth substance of very close and compact texture, in which there are no striæ nor traces of any fibres. With this latter substance, he thinks the external layer of these fossils exactly agrees: and he is confirmed in the supposition that it originally belonged to them, and was not derived from the matrix in which they lay, by observing that, in one specimen, several little flat shells of oysters were adhering to this surface.

Nothing, he thinks, in the fossil kingdom approaches so near to these fossils, as the single-starred corals of the Baltic, described by Fougt, and treated of in the former part of the present volume. The only difference, M. Guettard remarks, is that the corals described by Fougt have striæ which extend from the centre of the coral to the edge, in such a manner as to form a star. This difference is however sufficient to remove all idea of similarity between the two bodies; since, as we have already seen, the star constitutes the genus Madrepora, to which those corals belong, whilst in the fossil bodies now under consideration, there exist none of the characters which mark any of the species of zoophytes, which we have hitherto examined.

Many of these fossil bodies, it will be seen, differ so much from any known recent zoophyte, that were it not that vast numbers of these must be concealed from us, in the numerous recesses of the ocean, they would be concluded to possess not the least resemblance

with any animal substance now existing; indeed, so considerable is that difference, that some substances will be placed before you, which not only cannot be referred to any particular known species, but which would almost authorize the formation of new genera for their reception.

We shall proceed, however, as nearly as possible, according to the generally accepted systematic classification; and shall derive what aid can be obtained, from the examinations which have been made of living substances apparently of a similar nature. It is intended, therefore, to endeavour to comprise, under the genus *alcyonium* or *spongia*, the substances so accurately inquired into by M. Guettard, as well as several others which have not been spoken of by him, but are evidently of the same kind.

With respect to the classification of these bodies, a difficulty almost insuperable presents itself; since the characteristic marks by which the substances belonging to these two genera are distinguished, in a recent state, are frequently not to be discovered after they have sustained the change of petrifaction. Previously, however, to proceeding further in an inquiry on this subject, it will be proper to consider the nature of both alcyonium and of sponge, and to ascertain what are the distinctive characters of each.

The alcyonium is an animal which assumes a vegetable form, and which is either of a fleshy, gelatinous, spongy, or leathery substance, having an outward skin full of cells, with openings possessed by oviparous tentaculated hydra: the whole substance being fixed to some other body by a seeming trunk or root.

Count Marsilli, who carefully examined not only the physical, but the chemical properties of these bodies, observes that they are all surrounded by a porous leather-like bark: and that the interior substance is, in some, a jelly-like matter, and in others, a mass of light ash coloured acicular spines, which prick the hands on being handled, in the same manner as do the spines of the plant called the Indian fig.

Donati, in his Essay on the Natural History of the Adriatic Sea, has made, in some respects, a more minute examination of the structure of two different species of alcyonia than even that of Count Marsilli, and was enabled to ascertain by the aid of a magnifying glass, the peculiar forms assumed by the spines of which these animals are in a great measure composed. Of these we shall soon have occasion to speak more particularly.

The forms in which these animals exist are very numerous; this depending not merely on the number of species, but on the different irregular forms which the same species under different circumstances may assume. Thus, Marsilli observes, the same alcyonium, which sometimes grows flat, and thus covers large pieces of rocks, is at other times found in a rounded form.

From the different colours as well as forms which some of the species of these substances possess, they have obtained names expressive of their resemblance to certain fruits. Thus the *alcyonium lyncurium*, being of a globose form, of a fibrous internal structure, of a tubercular surface, and of a yellow colour, has been termed the sea-orange: the *a. bursa*, being of a sub-globose form, of a pulpy substance, and of a green colour, has been termed the green sea-orange or sea-apple: the *a. cydonium*, which is of a roundish form, and of a yellow colour, has been distinguished as the sea-quince: and the *a. ficus*, from a very close resemblance to the fig in its form, has been called the sea-fig.

The sponge is a fixed, flexible animal, very torpid, varying in its figure, and composed either of reticulated fibres, or masses of small spiculæ interwoven together, which are clothed with a living gelatinous flesh, full of small mouths or holes on its surface, by which it sucks in and throws out the water.

The vitality of sponges had been suspected by the ancients, even in the time of Aristotle; they having perceived a particular motion in their substance, as if from shrinking, when they tore them off

the rocks. This opinion of their possessing a degree of animal life was also entertained in the time of Pliny. Count Marsilli,* confirmed this opinion by observing, on their being taken out of the sea, a systolic and diastolic motion, in certain little round holes, which lasted until the water they had contained was quite dissipated. Mons. Peysonell supposed sponges to have been formed by certain worms, which inhabited the labyrinthean windings of the sponge; and believed that whatever life was found in these substances, existed in these worms, and not in the substance of the sponge, which he was convinced was an inanimate body. This point was, however, determined by Mr. Ellis, who, in a letter to Dr. Solander,† relates the observations which he had made; by which he ascertained that these worms, which he found in the sponge in great numbers, were a very small kind of *nereis*, or sea scolopendra; and that they were not the fabricators of the sponge, but had pierced their way into its soft substance, and made it only their place of retreat and security. Upon examining, in sea water, a variety of the crumb of bread-sponge, the tops of which were full of tubular cavities or papillæ, he could plainly observe these little tubes to receive and pass the water to and fro; so that he inferred that the sponge is an animal *sui generis*, whose mouths are so many holes or ends of branched tubes, opening on its surface; with these, he supposes, it receives its nourishment, and discharges, like the polypes, its excrements.

Mr. Ellis also discovered that the texture is very different in different species of sponge; some being composed wholly of interwoven reticulated fibres, whilst others are composed of little masses of straight fibres of different sizes, from the most minute spiculæ to strong elastic shining spines, like small needles of one-third of an inch long; besides these, he observes, there is an intermediate sort, between the

* Histoire Physique de la Mer, P. 53.

† Phil. Trans. Vol. LV. P. 280.

reticulated and the finer fasciculated kinds, which seem to partake of both sorts.

In the substances considered as alcyonia by Donati, as well as in some of those which have been described by Count Marsilli, similar large bundles of elastic fibres like needles were discovered. These had been reckoned alcyonia by most authors, but in Mr. Ellis's opinion they should not be so reckoned, since neither Donati nor Marsilli mention any polype suckers extending out of their pores; he considering the existence of these as the distinguishing character of the genus alcyonium, as much as the pores without the polypes in these elastic fibrous bodies is the character of the sponges.*

It is evident that these needle-like spiculæ cannot be considered as belonging to the genus spongia only; since among the alcyonia some are admitted to be formed of a spongy substance, into the composition of which these spicules may of course be expected to enter: on the presence or absence therefore of polypes in the cells of the substance must alone depend the necessary distinction.

But when the difficulty of distinguishing between the alcyonia and the sponges, even in a recent state, is considered, the oryctologist will easily find an excuse for his inability, to make a similar distinction between these substances, after they have undergone the lapidifying process: when their pores have become filled; and their colour and their substance, and, in fact, their whole nature has been changed. Indeed, the assumed generic difference between the alcyonia and sponges is such as must be entirely lost in most of these substances which have undergone the change of petrifaction. Whether the pores, which are discoverable in a fossil, were the dwellings of the polypous hydræ or not, can no longer be ascertained; since their radiation, which is supposed to characterize the openings in which these minute animals exist, and which is frequently so faint in the recent alcyonium

* The Natural History of Zoophytes, &c. P. 183.

as hardly to be detected, is very likely, in the fossil substance, to be still more difficult to be made out. Indeed, from this indistinctness of the radiation, much difficulty appears to have arisen in making the necessary distinction between even the recent sponges and alcyonia; the graduation from the perfectly radiated opening of the alcyonium, to the plain opening of the sponge, being so gradual and imperceptible, as to render it a difficult task, even where the substances are in a recent state, to draw the line where alcyonium ceases and sponge begins. But here is not the whole of the difficulty: several of the fossils, which will be presently described, possess some of the characters of ascidia and actinia, with those of the sponge or alcyonium; thereby rendering their distinct and correct classification almost hopeless. Hence, although I shall in general speak of these bodies as alcyonia, I am aware, that when their histories have been elucidated by the inspection of more illustrative specimens, several of them may claim other designations.

The consideration of another circumstance leads to the necessity of giving up every idea of distinguishing the alcyonia from the sponges, whilst in a mineralized state. Among the fossil zoophytes which claim a situation under one or the other of these genera, by far the greater number are such as are so totally different, from any known species of either alcyonium or sponge, as to render it almost impossible to determine under which genus they ought to be placed. Under these circumstances, you must perceive that the attempt to separate these fossils, by specific distinctions, at present, would be hopeless: it can only be effected when, by additional observations, their nature and forms are more perfectly known.

When it is recollected what very considerable variations in form, are found to take place in the recent individuals, of the several species into which these substances are divided; and when it was considered, that whilst passing into a mineralized state, their figure and appearance may be also much changed, it may be suspected that hardly any op-

portunity of fair comparison could be found, between the recent and fossil alcyonia.

This, however, is very far from being the case: and indeed when we reflect on the transmutation which has taken place; that a soft, gelatinous, or spongy substance, has become a hard and ponderous stone, we cannot but be affected with a high degree of astonishment; especially on perceiving that this great and extraordinary change of substance has been accompanied by so little change of form. In consequence of this I trust I shall be able to place before you many bodies, even in a silicified state, which will immediately appear to have been animals of this description, belonging to a former world. So great indeed will be the variety of these bodies, and so perfectly well preserved will they appear, as to render it necessary for me to say a few words, respecting the state of preservation in which they are found.

This is rendered necessary; since the comparatively frequent appearance of these bodies, in a fossil state, appears to contradict a position laid down in the former volume, whilst speaking of fruits, that substances possessing a pulpy consistence were not likely to be found in a fossil state; since their decomposition would most probably take place with too much rapidity to allow of that change being effected, on which their mineralization would depend. But a peculiarity of structure exists in these animals, which exempts them from the influence of this law. It appears, as we have seen from the observations of Marsilli and Donati, that these animals have blended, with their gelatinous and carneous substance, innumerable minute spiculæ, which may be considered as the bones of the animal. These manifest themselves by the prickling sensation they occasion, on being handled, which has obtained for some of these animals the name of the sea-nettle. That these spiculæ, formed of a hard and durable matter may, in some, and especially that the spongy fibres and coriaceous covering may, in others, keep up the form of the animal, for a sufficient time to admit of the petrifactive process being accomplished, seems

to be not improbable; and indeed appears to afford a satisfactory mode of explaining this curious fact.

That the bodies now about to be more particularly described are the remains of animals of a former world, seems to require no stronger proof, than the circumstance of these inhabitants of the sea being found in their changed state, in mountains much elevated above the level of the sea, and at a considerable distance from the situations which it now possesses. Whilst treating of the fossil corals, many were pointed out, whose recent analogues were positively not as yet known, and which were therefore conjectured to be the remains of certain species which might be now extinct. Any opinion of this kind with respect to these animals appears to be hardly admissible; since from the innumerable recesses in which they lurk, and still more from the comparatively small degree of eagerness with which they have been sought, we are totally unable to form any conjecture, as to the number of those which may have hitherto entirely escaped observation. Analogy indeed may lead us to conclude that by far the greater part of these fossil bodies are actually the remains of extinct species; but where evidence of a stronger kind cannot be also obtained, the fact must be considered as undetermined.

Having made these few prefatory remarks, I shall now proceed to a more particular examination of such fossils of this description, in my possession, as are most illustrative of the history of these extraordinary animals.

Those which are of a ramified form seem to be most rarely found in a mineralized state. The specimen, however, which is figured Plate VII. Fig. 12, and which was found in Berkshire, is undoubtedly the fossil remains of one of these species; although it is impossible to say to what particular ramified species it belongs, or whether indeed it is at all referable to any known species.

An examination of the substance of this fossil, now a mixture of silex and carbonate of lime, affords us internal evidence of its origin;

since its texture is such, as I have found almost constantly to characterize the fossil remains of any individual of this genus, which had been composed of a sponge-like substance. This substance has evidently, like sponge, been of a reticular texture; but the disposition of the meshes, if so they may be called, is in the spongy alcyonium much more uniform and determinate than in ordinary sponge, and though not to be described in words, the texture is so peculiar and characteristic, as directly to be known by those, who have been in the habit of examining these and similar substances, by the aid of magnifying glasses. The magnified appearance of its surface is shewn Plate VII. Fig. 7.

The fossil represented Plate VII. Fig. 6, and which is also from Berkshire, appears to bear a tolerably close resemblance to *alcyonium digitatum* of Linnæus; or the *dead man's hand*, or *dead man's toes* of Ellis. Its texture evidently appears to be of that kind, being finely reticulated, which would correspond with the carneous spongy substance, of which the recent zoophyte is formed. Its surface also, thickly beset with minute openings, bearing somewhat of a stellated appearance to the naked eye, serves to confirm the resemblance. This fossil is now a carbonate of lime moderately hard, but friable.

In the elegant work of Knorr, Mr. Walsh describes several fossil elongated alcyonia, by the silly term which the antients had adopted, of *priapolithi.* One of these from Touraine is figured Plate VII. Fig. 1. It had, at its superior termination, that opening observable in many of these animals, which served for the reception of the sea-water, from which, it is probable, they derived their support.

On rubbing down this substance on a sand-stone, at this termination, for the purpose of examining its structure, its hardness and the partial polish it obtained, proved, that it had suffered an impregnation with silica: and an examination of this surface with a lens plainly shewed that the flinty part was regularly distributed in continuous meandering lines, bearing the peculiar and characteristic form of the

spongy part of alcyonia, whilst the intervening spaces appeared to be filled by a softer substance, a carbonate of lime. The substance was therefore partly immersed in dilute muriatic acid, by which the calcareous part was speedily removed, with effervescence, and the silicious part left, possessing the fine retiform texture of the spongy alcyonium, surrounding the central opening already mentioned, as may be seen in the upper part of the figure.

The fossil represented Plate VII. Fig. 9, approaches the nearest, in its general form and appearance, to the *alcyonium cydonium* Linnæi, the *alcyonium primum* of Dioscorides, or rather to the representation of this animal as given by Donati. It must, however, be, I believe, considered as differing from any known animal of this genus.

This fossil is of a roundish form, rendered unequal by shallow depressions about the width of a finger, which pass from the superior to the inferior part of the fossil, and are separated from each other by tuberculated ridges. At the upper part has been a circular opening more than half an inch in diameter; and, at the lower part, is a rugged spot as though the pedicle had been here separated: a circumstance indeed which renders its affinity to the alcyonium described by Donati rather more doubtful. The substance of this fossil appears to be limestone which, probably from some tinge of iron, has obtained a reddish brown colour. It is not of a very close texture, apparently from the superadded calcareous matter not having accurately filled all the interstices between the fibres. Hence numerous small openings are, even in its present state, observable on its surface, which on close inspection are seen to be such as would result from a loose or spongy texture.

Whilst treating of the alcyonium, of the species to which this seems to approach, Donati particularly describes and delineates the curiously formed spiculæ which constitute a part of its substance. The body, as well as the cortical part, he remarks, is formed of two substances;

the one of which is fleshy, and the other osseous. The latter, he adds, is formed into spines; which, near the cortical part, are in great number, and closely intermingled; being about the length of two lines, and even longer. They are either of a fusiform figure, or are finely pointed at one end, and then gradually enlarge towards the middle: then, diminishing as they lengthen, they divide into three sharp conical points, around which are fixed numerous minute globular bodies, which are chiefly found in the cortical part.

A very strict examination, with a lens, of the surface of numerous fossil alcyonia, did not however discover any appearance of similar spines, and almost induced me to a ready concurrence with Plancus, who relates that he has dissected various bodies of this kind, and has seen the osseous fibres disposed in a radiated form; but as to the wonderful bark, the structure of which is so floridly described by Donati, he says, I have not seen it, and observes that the same thing has happened to him, with respect to the greater part of the figures in Donati's book, which, he says, are embellishments of the designer, drawn by the rule and compass, rather than in agreement with the truth and simplicity of nature.*

Being in possession of another specimen of this kind, formed of a much harder and closer stone, and which from its appearance I supposed to be invested with its cortical part, I resolved to sacrifice it to a more rigorous search for the spines described by Donati, concluding that, since all agreed as to their differing in their bony hardness from the other parts of this animal, I should at least discover some traces of them, although I might not be able to make out their form.

This fossil was therefore subjected to the only modes of dissection which I could employ with substances possessing a stony hardness. A polished section of it was obtained on different parts of it, and at

* De Conchis minus notis. App. II. Page 115.

different depths; by which the peculiar spongeous structure, already noticed as belonging to these bodies, was perceived; but no appearance of spines could be detected.

The specimen was then immersed in dilute muriatic acid, and examined at different periods, to ascertain whether the new surfaces thus obtained displayed any particular appearance. After rather more than a quarter of an inch of its substance was thus removed, I was pleased to find, with a lens of moderate power, several cruciform spines, formed, as it were, by two fusiform bodies, not an eighth of an inch in length, crossing each other at right angles, and terminating at each end in a very sharp point.

When these bodies were first discovered, the specimen was still wet with the water with which the acid had been removed. In this state they possessed a considerable degree of transparency, which they rapidly lost, as the water evaporated: so that when dry, they were completely opaque, and of a chalky whiteness. From their possessing this hydrophanous quality, and from their having withstood the action of the muriatic acid, there appears to be the greatest reason for supposing that these bodies, which were originally the spines of the animal, are now formed of an hydrophanous chalcedony, and imbedded in a matrix of carbonate of lime, which has pervaded or has supplied the place of the soft spongeous part. At Plate VII. Fig. 8, is a representation of the appearance which these bodies present when moderately magnified. This and the preceding fossil alcyonia are from Switzerland.

Alcyonium ficus, Linn. accurately depicted in the *Metallotheca* of Mercatus,* as *Alcyonium quintum antiquorum*, and particularly described by Marsilli as *Figue de substance d'eponge & d'alcion*,† resembles much, in form, the brown silicious fossil, Plate IX. Fig. 4.

* Arm. 6. C. 6. P. 102.

† Histoire Physique de la Mer. P. 87.

The recent alcyonium, according to the Count, is of the form of a fig, being attached to the rocks by branches proceeding from its smaller end; its upper part being a little flattened, with a hole in the middle. Its colour, he says, resembles that of tobacco, and its parenchymatous substance, he thinks, cannot be compared to any thing better than to nutgalls, when well dried. In all these respects, a very exact agreement seems to exist between the recent and fossil substances. Still, however, the fibres running over its surface, and penetrating its substance, with the grooves which appear to have been formed by other fibres, which are now removed, distinguish it, not only from this, but, I believe, from all known alcyonia. This fossil is from Wiltshire, and appears to be formed entirely of flint.

The fossil, Plate IX. Fig. 3, from Mount Randenberg, near Schafhousen, in Switzerland, possesses evident marks of its alcyonic origin. This fossil, like those of the ramose kind, figured in Plate VII. has that reticular texture, which appears to be peculiar to the spongy alcyonia. In this specimen also, as well as in those, the reticular fibres are impregnated with silica, and have their interstices filled with calcareous matter. In this, as in the fossil last described, the remains of the pedicle, the organ, by which its attachment to its appropriate spot was accomplished, are observable; as well as the superior opening, which passes deep into the substance of the fossil.

The fossil represented Plate IX. Fig. 5, and which is from the neighbourhood of Saumur, being a very perfect fossil of the kind described by Mons. Guettard, agrees, in its general characters, as well as in its texture, with that one which has been just described. In this specimen, at its superior surface, there are, as Mons. Guettard observes is sometimes the case, four openings; and the pedicles, as well as its lateral processes, which appear like roots, seem to have been formed with a great degree of luxuriance.

A very perfect fossil of this kind, and similar in its substance and texture to the alcyonia, which have been just described, but of a dark

red colour, where it is not invested with its cortical part, which is of a grey colour, pervaded by a slight tinge of red, is represented Plate IX. Fig. 8. The pedicle and the opening at the superior part are here very perfect. Slight traces of lines, passing from the pedicle to the opening, are discoverable on this specimen, and doubtlessly point out the arrangement of fibres, by which the animal was enabled to draw in and eject the water which supplied it with food. This fossil, I have reason to believe, is English.

The set of fossils, which I shall next place before you, is, in many respects, extremely interesting. In the general outline of their form, many of them so much resemble the fossils last described, as, at first sight, to lead to the supposition that they are only varieties of the same species; but, on a closer investigation, several circumstances are observed, which seem to warrant a contrary opinion.

The following are the most remarkable circumstances, in which these fossils differ from the former. First, They appear to be almost entirely silicious. Secondly, In that part of the fossil, in which an opening existed in the former species, a rather prominent substance is found. Thirdly, Instead of the finely granulated surface possessed by the former, which appears to have been produced by innumerable minute openings, passing into the substance, the surface is, in the latter, such as might be expected to result from the instillation of lapidifying matter, into a substance of spongeous texture, embraced by numerous ramifying filaments. Fourthly, An entire difference in their internal organization.

One of these fossils is represented, Plate IX. Fig. 12, with its longitudinal section, displaying its internal organization. The general figure of this fossil approaches very nearly to that of the fossil last described; or, perhaps, it may be considered as bearing a nearer resemblance to a fig. Its spongy alcyonic texture is observable, not only on its polished internal, but on its rough external surface; and like the preceding fossils, it appears to have terminated at its lower end in a gradually diminishing pedicle. At the centre of the superior part,

in a small depression, is a slightly projecting substance, appearing like that part which is termed the eye in pomaceous fruits. From this substance proceed numerous ramifying raised lines which spread over the whole surface of the body, and are collected together towards the pedicle. The manner in which these ramifications go off from the centre is more plainly shewn in Plate IX. Fig. 11.

On viewing the polished section of this fossil, as here represented, it is plainly seen that the general substance of this petrified body was originally of the alcyonic spongy nature. Numerous fibres are also seen proceeding from the projecting body at the superior part; some of which pass straight on the opposite surface, and others directly to the sides; whilst others diverge immediately, pass along the superior part, and then, spreading over the external surface, embrace the whole substance of the fossil.

In very few instances can the assumed sportiveness of creative nature be illustrated better than in this series of fossils. Every mode seems to have been here adopted to mislead the observer, and to occasion him to consider as a vegetable, a substance which, in its original state, doubtless owed its existence to the energies of animal life alone. To lead to the general idea of a fruit, we have the pedicle bearing the appearance of a stalk, and a substance in the opposite surface resembling that which is termed the eye of the fruit. In their general forms are seen the resemblances of pears, apples, figs, &c.; and in some, marks on their surface, giving a similar appearance to that of the nutmeg. In all, the internal substance appears like the parenchyma of fruits: and in some, fibres like those of the ligneous kind are seen traversing through; whilst in others, small bodies, like the seeds of fruits, are seen imbedded in the midst of this substance.

Thus we perceive that animals may be endued with forms, and may even possess internal organization, so different from those of the generality of animals, that they shall more resemble the subjects of the vegetable than of the animal kingdom, and yet shall be so consti-

tuted as completely to perform the offices allotted to them in the rank which they hold in the scale of creation.

This wonderful and close analogy also offers to our admiration a plain demonstration, not merely of the power and of the wisdom of our great Creator, but of the rich infinity of resources from which he has been enabled to diversify his works. But to return to the animal, the examination of which led to these reflections. It differs from the alcyonia already described, in having no particular cavity for the reception of the sea-water. We are, however, fully authorized in considering this and all the rest of this series not merely as sponges, since they possess, beside the spongy parts, a more complicated apparatus for procuring the reception and ejection of the sea-water, the vehicle of their food.

In this particular animal, an admirable contrivance appears to have been employed for the performance of this function. In the alcyonia already described it was remarked that, at their superior parts, an opening was always to be found, and from the sea-water received in this cavity bearing an analogy with the stomach of the more perfect animals, the necessary portion of nutriment was supposed to have been derived. But in this body no particular cavity seems to have existed; the sea-water imbibed by the spongy substance of which this animal body was composed, as most probably ejected by the contraction of that body, aided by the additional compression derived from the contractions of those filaments, which we see pass through its substance and over its surface; and which, probably possessing the properties of a muscle, would occasion a regular alternate contraction and dilatation of the cavities, by which a perpetual renewal of its matter of nourishment would be obtained.

I am, unfortunately, unable to speak positively respecting the place where this fossil was found: I have, however, great reason to suppose it was obtained from some of the gravel-pits in this island.

The fossil depicted Plate IX. Fig. 11 and Fig. 13, evidently belongs

to the same species with the last described: a difference is, however, observable in the appearance of the two fossils. This fossil, which is silicious, has been divided transversely by the lapidary. Fig. 11 represents the external surface of its superior part, and Fig. 13 the polished interior surface of the inferior part. In Fig. 11 it will be seen that a slight cavity appears in that part in which, in the former fossil, Fig. 12, a moderate degree of prominency had been formed: and that in this fossil ramifying depressions are perceived in that part on which, in the former specimen, raised ramified filaments are to be seen. On the polished surface of the interior part, numerous minute cavities are observable, and which, particularly near to the centre, resemble the little chambers for the lodgment of the pips or seeds of the pomaceous fruits.

These appearances and apparent differences seem, however, to be sufficiently easy of explanation, without having recourse to the supposing of any difference between the two original bodies, from which the two fossils have proceeded. It appears to be exceedingly probable that, in the former fossil, the silicious impregnation, which appears to have been to saturation, had pervaded not only the whole of the spongeous part, but even the harder filamentous part; whilst in the latter fossil, the silicious impregnation which seems to have been much less abundant, has only impregnated the spongeous part and the filamentary part, not having been thus impregnated, has not been preserved.

The fossil Plate IX. Fig. 1, which is a dark flint found in one of our English chalk-pits, and which derives from the chalk the colour on its surface, is a highly interesting and instructive specimen of this species. The numerous ramifying filaments proceeding from the circular body at its superior part all terminate in, or rather appear to pass beneath the line which is formed by a seemingly added substance, which covers the whole of the inferior parts. The feeling yielded by the handling of this specimen excited a suspicion as to the nature of the substance with which it is partially invested. On being handled, it occasions a

sensation, as if its surface were beset with innumerable minute asperities, a sensation which I had been accustomed to feel, whilst handling such petrified alcyonia as had not suffered from attrition, and which appeared not to have been deprived of their cortical part. I am therefore led to believe that, on this fossil, a considerable portion of the original cortical part still remains; but which has been entirely removed from those which have been just described. I am also induced to suppose, from the appearance of this fossil, that the surrounding ramifying filaments were disposed between the cortical part and the body of the alcyonium; and that, besides the office just attributed to them, they also served to connect the cortical investing part with the included spongy mass.

The fossil, figured Plate IX. Fig. 7, appears to have been of the same species, and is, in many respects, exceedingly interesting. It has been imbued with silicious matter so transparent, that its highly polished transverse section displays the internal structure of the alcyonium as plainly as it could have been discovered in the recent animal itself. The greater part had evidently been of a spongy texture; the spongy substance itself being most distinctly visible with a lens of a moderate power. Through this substance, several interrupted lines, as the figure will shew, pass in regularly disposed radii from the centre to the circumference, and an examination of these with the magnifying lens, gives every reason to suppose that they are distinct from each other, and are transverse sections of those fibres which, passing from one part of the body to the other, have, by supporting it, served to preserve its form. They also have probably been fasciculi of muscular fibres, and may have served, in the living animal, to have produced that alternate contraction and dilatation of the external openings of this animal, which we have already spoken of, and which Marsilli has observed to take place in the external openings of sponges, when filled with the water on being taken out of the sea. Another observation of this same ingenious naturalist also leads to the supposition, that this con-

jecture, as to the use of these fibres, is well founded. In cutting with a pair of scissars a recent alcyonium, which in many respects resembled the present fossil, and which he calls the Sea Orange, (Alcyonium bursa, Linn.) he remarks that he perceived a motion in every part of it as if it were alive.* On tracing these filaments, many of them may be seen passing to the surface, on which, after ramifying, they are so disposed as to embrace the whole mass.

The fossil zoophytes we shall next examine appear to be of a different species from those last described: the difference chiefly existing in the retiform disposition of the filaments surrounding the alcyonic mass. Like those of the former species, these fossils are formed entirely of silicious matter, and appear to have been found in gravel. It is evidently to one of these bodies that the following description from Dr. Woodward applies:

"*C.* 252. A greyish brown flint of an obtuse conic figure; an inch in diameter at the base, and about three-fourths of an inch in height. In the middle of the base is a round flat, about four-tenths of an inch over, and somewhat raised above the rest of the base. The whole surface besides is very rough, being thick set with very small pores, excepting certain smooth ridges that run into one another, so as to constitute an elegant reticulated work upon it. Found near Rumford, in Essex."†

On inspecting the fossil figured Plate IX. Fig. 9, it will be found to correspond so exactly with the foregoing description, as to require no other. The figure, here given, serves to furnish a tolerably correct idea of the external appearance which this species of fossil in general presents.

From the appearance yielded by the section of this fossil, as shewn

* Histoire Physique de la Mer. P. 80.

† An Attempt towards a Natural History of the Fossils of England, by J. Woodward, M.D. Vol. I. Part I. P. 51.

Plate IX. Fig. 10, the internal structure of these bodies appear to differ much from that of the preceding fossils. The zoophytes, from which these fossils have derived their form, appear to have been hollow, and the substance, of which their surrounding part has been composed, appears also to have differed from that of the other alcyonia, in being made up, as is seen by examination of the polished surface with a magnifying lens, of minute quadrangular bodies, exactly fitting each other. The cavity, which must have been answerable to the darker central part in the figure, and which, in this specimen, is filled with transparent yellowish flint, appears to have been of an irregular form, dependent on the general shape of the including substance, and of the processes, which are seen passing towards the centre. By what openings the admission and the ejection of the sea water were secured does not appear to be discoverable.

Plate IX. Fig. 6, represents a most perfect and beautiful fossil of this species. The reticulated work has been regularly disposed over its whole surface, but appears to have been removed ; it has, however, left regular indentations and markings, which give it a very elegant appearance. A view of this fossil will evince how excellently adapted this kind of reticular covering must have been to accomplish the alternate compression and dilatation of the substance of the alcyonium, on which its existence seems to have depended.

Plate IX. Fig. 2, is a fossil of this same species, which is rendered interesting by a considerable portion of its surface being covered by a smooth coat, which, like the seeming superadded substance, described in the fossil Fig. 1, seems to agree exactly with cortical covering of the alcyonium. It is equally difficult to determine whether the reticulated filaments of this, or the ramifying filaments of the former fossil, in the original animal substance, passed under the cortical part, or whether the cortical part was continuous with, and was formed, as a production of the ramifying filaments, in the one instance, and of the reticulated filaments in the other.

The small light-coloured, calcareous, spongite, or alcyonite, Plate IX. Fig. 14, possessing somewhat of a conical form and a rugose surface, and exhibiting, when examined with a lens, evident marks of an original spongeous substance, was obtained, by Mr. Strange, from Switzerland. A specimen, approaching exceedingly near in size and form to the one here figured, was suspended in water slightly acidulated with muriatic acid. As the acid acted on the carbonate of lime, the membraneous part of the sponge began to appear; and being liberated, extended itself beyond the remaining solid mass, in tolerably coherent flexible flocculæ. When it had been submitted so long to the action of the acid, that the carbonate of lime was nearly removed, a dark brown reticular mass was left, bearing the general form of the fossil, and manifesting its original spongeous reticulated texture. So coherent was this mass, as even to bear its removal, by pouring into another glass, without suffering any material injury to its form. It was, however, at last broken, upon pouring additional water into the phial which contained it. Another specimen, as similar in its form and size as could be found, was then subjected to the action of the acid for the purpose of obtaining a correct sketch of the remaining membrane, which is given Plate IX. Fig. 15.

The small calcareous fossils, Plate X. Fig. 7, 8, 9, and 10, are from the Canton of Basle, in Switzerland. Their animal origin is rendered evident by their alcyonic structure as discovered by the aid of a lens. The specimen of a hemispherical form, delineated at Fig. 8, has a central stellated opening, which has every appearance of having been the residence of a polypous hydra, and which is surrounded by radiating depressions, such as would seem to agree with the arms of the animal. On close inspection, it is seen, that the whole substance of the alcyonium is closely beset with innumerable minute openings, which, in all probability, teemed with these extraordinary animals.

The natural history of these substances teaches us, that individuals of different species are frequently found growing adherent to each

other. An instance of this kind is observable in this specimen, where this small hemispheric, stellated alcyonium is seen connected into one substance with another alcyonium, which is of a flat and tabular form.

The fossil alcyonium, represented Plate X. Fig. 7, differs from the former, in its central cavity terminating in a regular circular opening; but the openings on the rest of its surface have the stellated form, which so plainly denotes their having been the residence of polypous hydra. A similar circular opening terminates the central cavity in the superior part of the oblong alcyonium, Plate X. Fig. 9. The pedicle by which it had been attached to some other body is very distinctly to be seen.

The triquetral pyramidal alcyonium, Plate X. Fig. 10, has been raised on a pedicle, the remains of which are very distinct. It has no central opening, but is closely beset, all over its surface, with very minute circular pores, only discoverable by a strong magnifier. These pores give to its surface that resemblance to shagreen skin, which, as Mr. Walch observes, so generally characterizes the fossil alcyonia.

LETTER XII.

FOSSIL ALCYONIUM DESCRIBED BY ABBE FORTIS.....SPECIMENS OF VARIOUS INEDITED FOSSIL ZOOPHYTES DESCRIBED.

Justice to the Abbé Fortis impels me to remark that the observations here adduced on the fossil alcyonium, depicted Plate X. Fig. 11, are derived from a manuscript tract, which I was so fortunate as to purchase at the sale of the late Mr. Strange's library, and which, I have every reason to believe, proceeded from the pen of that excellent oryctologist. The specimen here represented I also obtained from the previous sale of the fossils of Mr. Strange, and it appears to be the more valuable from my not having seen any similar specimen in other collections. The above-mentioned tract was accompanied by a plate exhibiting the specimens, now in my possession, with four others, shewing the same substance adherent to different shells. According to the Abbé's account, this species of fossil alcyonium commonly forms a covering to shells, and is most frequently seen on a species of nerite. These fossils are found in different parts of Tuscany: the Abbé himself has not only seen them in the neighbourhood of Volaterzano, and in a chalky tract towards Sena, which the inhabitants call *Le Biancane*, but in some others of the Tuscan hills; and he once saw a specimen of this kind, which had been found in that neighbourhood, in the museum of Ferdinand Bassi of Bologna. But these fossils are chiefly to be found in the hills of Cerretani, which lay towards Ficeclum, being brought to view by the washing away of the earth by rain. It was from this spot that the specimens which I possess were obtained. It is worthy of observation, that Mercatus does not

appear to have known of this fossil, although he relates, that he had received from his father many fossil shells which had been dug up in the fields of Miniato, near to the hills of Cerretani.*

This fossil is of a yellowish white colour, and of a roundish tuberous shape, it being furnished with several processes of different sizes, which terminate in different ways; some being rounded, and others flattened. An opening of somewhat of an oval form, answering to the mouth of the shell which it invests, exists on that side which is free from the processes just mentioned. By the side of this opening three of the branches terminate abruptly, as if broken or worn down, shewing that they are internally of a laminated structure. Upon examining the surface with a magnifying glass, it is found to be granulated by innumerable minute risings, bearing somewhat of a mammillated appearance. Innumerable minute openings are also seen over the greater part of the surface, and many of them in the centre of the risings just described.

This alcyonium is formed on a nerite, which is the case also in the two other specimens which I possess; the nerites, thus incrusted, bearing every appearance of fossil shells. This kind of shell, the Abbé observes, is the most frequent nucleus of this fossil alcyonium, found in these hills; but he has also seen specimens enclosing other univalve shells.

A curiously formed fossil alcyonium is depicted Plate X. Fig. 6; it is now composed of a very dense limestone, the hardness and weight of which, as well as the colour, sufficiently evince that it possesses a very considerable portion of iron. From its inferior tapering part, which is a portion of its pedicle, it gradually swells, and is then continued, in a flattened cylindrical form, about four inches, when it gradually contracts and terminates in an irregular surface, perforated with several small circular openings. Other openings, much smaller than these,

* Metallotheca Vaticana, Page 129.

but in all probability connected with them, are observable on the fractured part of the pedicle, and the whole surface is so closely beset with openings, as small as the smallest pins' heads, as to give it very much of a spongy appearance. The only information I can obtain respecting the locality of this fossil, is from its being designated an *English long fungus.*

Possessing two other fossils of this species, and one of these being formed of a tolerably transparent calcedony, I have been able, by its section, both longitudinally and transversely, to obtain some knowledge respecting its structure. The form of the fossil subjected to this examination seems to have approached very nearly to that which has been just described. Its substance has evidently been of a spongy nature, as is shewn by an inspection of the polished calcedonic surface with a magnifying lens. This substance, however, appears to have been not more than one-fourth of the thickness of the alcyonium in the central part, but in the inferior part has been thicker, and the superior part seems to have been filled by it. Through this superior spongeous part, a great number of openings are observable, which appear to have opened into the large central cavity, where, as has been already observed, there was a deficiency of the spongy matter. Into this cavity innumerable openings, which are on its surface, also seem to have penetrated; and several tubes, which arose from the inferior part, pass through it, and have their openings at the upper surface of the superior spongy part. To attempt to explain any particulars respecting the offices of these respective parts, would be vain; it may, however, not be amiss to remark that every necessary arrangement seems to have been here made, for the ingress and egress of the fluid, in which the nutriment proper to these animal bodies is contained.

Still less successful must be the attempt to form any conjecture, respecting the habits or the peculiar nature, of the living being or beings, whose existence was connected with the animal substance which formed

the basis of the fossil, depicted Plate X. Fig. 5. Its general form and tuberculated surface, with the risings and depressions passing from one end to the other, give it an appearance so much resembling a cucumber, that, in the minds of those who were not a little conversant in these inquiries, suspicions might arise, that it owed its form to that fruit.

By rubbing a part of it at one of its terminations with a sand-stone, I ascertained that it was hollow, and that the substance of the fossil was about a third of an inch in thickness. On examining this fossil, by attrition on different substances, and in various other ways, it was discovered to be composed of a loose, spongy, calcareous matter, combined with a very small portion of silicious sand, and incapable of acquiring a polish. On several parts of its ashen grey-coloured tuberculated surface, patches of a thin pellicle, of a reddish yellow cast, were discoverable; and the magnifying lens shewed that a depression, and even an opening, were observable in the centre of some of the tubercles. At one end, which in the plate I have made the superior, no imperfection appears; but at the other end a surface is observable, from which, it seems, that a part has been broken off; and on that surface, the lens demonstrates strong marks of organization.

From the texture of the fossil itself, and from the appearances at its inferior termination, the cellular, spongy, organized original body may be inferred; and from the apparent fracture at the same termination, the existence of a pedicle at that part may be supposed. Additional reasons for supposing it to have been organized, in a manner similar to alcyonia, may be deduced from the openings, observable in some of the tubercular risings, and in the thin cortical part, the remains of which are so distinctly to be seen.

But the circumstance which serves most of all to corroborate this opinion respecting its origin is, that Count de Marsilli describes a recent alcyonium, which agrees in all its essential characters with this

fossil. The figure of this alcyonium, as given by the Count, is such as would lead any one to say that it bore a nearer resemblance to a cucumber than to any thing else. At its inferior termination are several projecting parts, which the Count describes as branches, but which, as is shewn by the figure given by the Count, do not deserve such an appellation; since, from their extending so trifling a distance from the general surface, they can only be considered as protuberances, of which many are to be found over the rest of the surface, having a depression in their centre. Its interior part was hollow, the substance consisting only of a coriaceous bark or shell, of an ashen grey, mixed with a straw colour. When first taken out of the sea, it was not filled with sea-water, as the Count found was the case with the sea oranges, but only contained a small portion of a glutinous matter. To preserve the specimen in his cabinet, the Count filled all the cavity with cotton.*

By comparing the account of the recent alcyonium with that which I have given of the fossil, I trust that in their form, structure, and colour, the resemblance will appear to be sufficient to authorize the belief of their relationship.

In some of my earliest researches in the gravel-pits in the neighbourhood of the metropolis, my attention had repeatedly been attracted by a certain species of pebbles, which, from their general uniformity of character, I was convinced, must have owed their form to either vegetable or animal organization. I therefore collected a considerable number of them, hoping that, by frequently repeated examination and comparison, I might be enabled to form some probable opinion respecting their origin: my endeavours, however, were by no means productive of that satisfaction which I wished.

These pebbles, Plate X. Fig. 14, 15, 16, in general approach to a rounded conical form, one termination being wider than the other.

* Histoire Physique de la Mer. Page 86, P. 15. n. 76, 77, 78.

The edge of the upper part, or that which forms the base of the cone, is either pierced with several holes, or else is marked with traces of holes, which are now filled up with flint. The lower termination, which forms the apex of the cone, is also either pierced with one, and sometimes with two holes, or bears marks which shew that such openings have existed, but have been since filled up by silicious matter. The specimen, Fig. 15, will give a tolerably correct idea of the general appearance of these fossils.

Anxious to obtain what knowledge I was able respecting the formation of these pebbles, I broke many of them in different directions, and was thereby enabled to ascertain that their shape and their openings depended on the figure of a body, which they contained in a cavity in their central part. This was, of course, seen with more distinctness in those which, as in Fig. 16, had been broken in a perpendicular direction.

By the aid of the opening made by fracture, Fig. 16, some of the remains of this body will be seen. It will be there perceived, that it is formed by a congeries of tuberculated tortuous filaments, which, by intertwining with each other, form, in the apex of the cone, which I presume to have been the inferior part of this body, a closely reticulated columniform body, which, after having proceeded less than an inch, appears to have separated into about a dozen ramifications formed in a similar manner. At the superior part, on the side, a portion is still adherent, in which the original characteristic forms of the ramifications of this body may still be seen, bearing a slight resemblance to the formation of the fan sponge.

That this body has derived its origin from some lost species of alcyonium or of sponge, I am firmly of opinion; and trust that in this opinion I shall be joined by those who are acquainted with the characters of these two genera. Positive evidence will not be obtained until the nature and form of this body is ascertained in some more perfect specimens: the difficulty of procuring which is considerable,

in consequence of the fragility of the inclosed body being such, that it is almost always very much shattered by the blow which is necessary to break the pebble which incloses it. In the meantime, the regularity and constancy of the form which it bears in the multitude of its specimens which may be met with, is no small proof of its having derived its form from some organized being.

The constant uniformity of the figure which this substance bears is by no means offered as a proof alone of its animal origin; since, as in the instance of the Ketton and other stones, a constant uniformity of figure is observable, without any reason appearing for supposing them ever to have existed but as minerals. A circumstance, however, is observable in these pebbles, as has been already slightly noticed, which at least proves three distinct stages in their formation; and also tends to confirm the suspicion of the inclosed body having existed in a distinct state. The openings in the pebble, through which the processes have passed, plainly shew that this body must have previously existed, and that it has been a nucleus, on which the surrounding silicious matter has been deposited. Those marks in the pebble, too, where traces only of these openings can be seen, the openings themselves being filled up by silicious matter, shew that an addition of this silicious matter, in a fluid state, has been made, after the pebble had been formed round this nucleus, and after the projecting bodies, which had filled those openings, had been removed by some force.

At Fig. 14, a representation is given of the appearance which some pebbles derive from this body. It is at the wide superior extremity, where the processes have passed, that meandering lines are discovered. These seem to have been formed by the concurrence of the edges of two or three openings, which have been filled up by silicious matter.

I am fully aware of the scepticism with which my conjectures on the nature of the preceding fossil will be received: that a substance so lit-

tle resembling any known animal substance should be allowed a place in this part of a work, will not, by many, be readily admitted. By those, however, who are aware of the vast variety of forms which this animal matter assumes, the probability of its having been the origin of this fossil will not, I trust, be denied.

I have some reasons for supposing that the termination of this substance is in small and very numerous ramifications; and that these ramifications occasion the small tubuli and foramina perceived in certain pebbles which are frequently found among the gravel. To these terminations of this fossil, I also attribute the light-coloured ramifying veins, observable on the fractured surfaces of some pebbles: the vacuities which those pebbles originally acquired, by having been formed on those ramifications being filled up by subsequently added silicious matter. These, however, are conjectures too little supported by observation to be insisted upon.

Not less problematical than that of the last is the origin of the fossil Plate X. Fig. 12. The one which is here figured was formerly in the collection of Mr. Strange. These fossils are formed of chalk, and generally have somewhat of a conical figure, the apex of the cone being rather rounded. The surface is very closely beset with small depressions, pretty regularly disposed in somewhat of a quincunx order. From cursory observation I had been led to suppose this fossil to have owed its origin to either a flustra or millepore: but, on close inspection, especially with a glass, I found reason to dispose it among the alcyonia. That it was not a flustra I concluded from being able, as I imagine, to trace its organization to some depth into the chalk; and that it was not a millepore I was satisfied, from perceiving that, with the glass, the substance interposed between the pores had every appearance of alcyonic or spongeous structure. I have since obtained a similar fossil by the kindness of Mr. Cunnington, from the chalk-pits of the northern parts of Wiltshire.

There is no one among the fossil zoophytes which displays a more

curious structure than that which is discoverable in the very rare fossil Plate X. Fig. 1, 2, 3, 4. It is a tolerably fine lime-stone, nearly of a hemispherical form; and, according to the best information I can obtain, was found in some part of Switzerland. Its superior convex surface, represented Fig. 4, has a groove, about a third of an inch in depth, and as much in width, which possesses about three-fourths of its length. The whole of this superior surface derives a smooth downy appearance, from innumerable fine striæ, formed by very minute articulated fibres, which proceed from the inferior surface, pass round every part of the circumference, and collect together and terminate in the sides of the central longitudinal cavity. At Fig. 3 is given a magnified view of a part of this surface, in which may be seen the appearance of articulation observable in the fibres of which it is composed.

The inferior surface is nearly flat, and is seen, with the naked eye, to be marked by completely concentric ridges and corresponding depressions, intersected by numerous lines, radiating from the centre to the circumference. On employing a magnifying glass, it is discovered, as may be seen in the sketch, Fig. 1, that the cylindrical fibres are continued, from the superior convex surface, to the centre of this inferior surface, and are connected, laterally, by fine transverse linear processes, circularly disposed, as is represented, moderately magnified, Fig. 2.

Having, fortunately, two of these curious fossils, I was struck with a considerable difference in the appearance yielded by their inferior surfaces. The circular ridges were more prominent, and, of course, the depressions were deeper in one than in the other; and in that one, a concavity in the centre of the inferior surface was also observable, which did not exist in the other. I was led by these differences to conclude that they had originated in a power, which had been possessed by the animal, of effecting certain changes in this surface, dependant on the particular circumstances under which it might have been placed.

A striking peculiarity observable in this fossil, is its complete devi-

ation from the other fossil zoophytes which we have noticed, in its not possessing a footstalk or pedicle, by which it could have been attached, like them, to any other substance. A little attention, however, to the organization of this animal mass, will, I think, discover that such a structure has been here employed, as was well calculated to afford a very efficient substitute for the pedicle, with which we have seen that the alcyonia have been furnished. It has appeared, in the course of our inquiries, that the animals of the alcyonic kind are destined to derive their sustenance from the various contents of the sea-water, a frequent renewal of which is procured by the power which they possess of alternately drawing it into, and ejecting it from, certain cavities in the substance which they animate. This process must of necessity be effected by the operation of muscular fibres, disposed in such directions as are best calculated to produce the desired effect. But that these muscular parts may act with a greater degree of force and energy, it is necessary that they should be attached, at one of their terminations, to a fixed point; towards which, the parts attached to their other termination may be drawn by their contraction. Hence we find that all the alcyonia we have hitherto described have been fixed to some other substance, by a pedicle, not much unlike, in its appearance, to the root of a shrub.

A view of the arrangement of the tubuli or fibres, in the particular species now under our examination, will instruct us in the mode which has been employed, in this animal, to establish a fixed point from which the fibres might act; and at the same time, to allow the power of removal from one place to another. Supposing the animal laid on its inferior surface, on any substance wet with the sea-water, a retraction upwards of the fibres, about the centre of that surface, would, of course, produce a cavity, and a vacuum between that surface and the surface of the body on which the alcyonium was placed; in the same manner as it is produced by pulling the string in the centre of the leathern suckers of children. Thus would be occasioned so strong

a degree of adhesion, that, whilst the animal secured this vacuum, no removal of it from that spot could take place, unless accompanied by destruction of the parts of which it was composed. On the other hand, whenever the animal was disposed to submit itself, with its dwelling, to the direction of the waves, it would only be necessary to contract the perpendicular fibres terminating on the edge of the inferior surface, by which that edge would necessarily be raised ; and by continuing this process through each successive circle towards the centre, the air would gain access to the vacuum, and the animal would be immediately loosened. Whilst affixed by its inferior surface to any other substance, the whole of its circumference would be formed into as many fixed points as there are fibres proceeding up its superior surface. These fibres, thus fixed at their inferior part and terminating in the sides of the longitudinal cavity on the upper part, would, by their contraction, draw downwards the whole alcyonic mass, and at the same time widen the central longitudinal opening, by which action the contents of the ventricular cavity must have necessarily been expelled. The relaxation of these fibres would of course be accompanied by the refilling of the cavity, and by the alternate contraction and relaxation of these fibres, the alternate filling and emptying of the ventricular cavity would be effected.

The probability that the animal possessed this power of thus forming a vacuum, and of fixing itself, like the remora, or sucking-fish, is rendered exceedingly probable, by both the specimens which I possess, as has been already observed, having on their inferior surface concavities, not only differing in their magnitude, but also in their form, arising from different circles of the series having been more or less acted upon, by which corresponding risings and depressions have been left. From the rarity of the fossils, I was not disposed to institute any examination of them which should, either chemically or mechanically, injure their surface.

LETTER XIII.

ALCYONITES AGREEING IN THEIR FORMS; BUT DIFFERING IN THEIR STRUCTURE......SPECIMENS OF FROM FRANCE, ITALY, SWITZERLAND, AND ENGLAND......WILTSHIRE ALCYONITE.

The fossil alcyonium, which I next present to your notice, is considered as very rare, both by Mons. D'Annone and Mr. Walch. It is figured in Knorr's elegant work, Tome II. Planche, F. 3, from a specimen obtained, as were those in my possession, from Randenberg. This fossil is figured Plate XI. Fig. 2, where it will be seen approaching to a hemispheric form: its lower part, where was its pedicle, being somewhat conical, and its superior part, which is somewhat rounded, having a considerable cavity in its centre. The substance of the fossil is divided into numerous lamellæ of considerable thickness, perpendicularly disposed round this centre, and concentrated at the conical projection in the inferior part. Between these lamellæ are grooves of about a quarter of an inch in depth, which are transversely divided by grooves less deep, and much more irregularly disposed.

Anxious to obtain some information respecting the structure of this strangely formed mass, I devoted one of the curious specimens which I possessed to suffer the required examination. By means of attrition on a sand-stone of considerable hardness, a polished section was obtained on its superior part. On examining this carefully with a lens of considerable power, the substance of the alcyonium appeared to have been formed in this part of minute tubes, opening side by side, in lines crossing each other at right angles. To illustrate this arrange-

ment a part of this surface is shewn, Plate XI. Fig. *a*. Another section was then made across the inferior part, where it began to terminate conically, and here also the lens made an exactly similar structure appear. Having thus obtained two transverse sections of these tubes, I expected, by obtaining a section in the direction of the sides of the fossil, to procure a longitudinal section of these tubes, but I was surprised to find, after the necessary operations, that the appearance yielded by this surface was exactly similar with that of the two former; it seeming that these tubes or vessels had their openings, in the same manner, on every part of the surface.

The examination of the structure of the several fossil alcyonia, which have preceded the present, has shewn that it has been such in all as was best calculated to furnish the inhabitants of these substances with an abundant renewal of sea-water, fraught with the animalculæ or other matters, which would afford them nourishment. A very slight degree of consideration will be sufficient to discover that the form and structure of the present fossil is such as would accomplish this purpose in a manner the most complete. The whole surface, we see, is covered with the minute openings of tubuli, of which the substance is formed: and these are connected in fasciculi, which, being disposed in a radiated form, round the large ventricular opening, might, in the original alcyonium, by a pulsatile action, a regular systole and diastole, have procured a rapid succession of sea-water, teeming with the proper nutritious matters; the water received in the ventricular cavity being thus expelled by the vessels opening all over the surface. The substance of this fossil appears to be lime, argil, and silex, in intimate combination.

The account of this fossil, given by Mr. Walch, in Knorr's work, is very short. He merely thus describes it in the words of M. D'Annone :—" Ce fongite est a peu pres de la forme d'un hemisphere ; du sommet partent des sillons separés par des rides saillantes ou des lames epaisses, qui descendent a la circumférence de la partie platte

de dessous, & forment en traversans le bord, & en tirant vers le centre, une quantité des plis irreguliers. Au milieu de sa base ce fongite a une grande & profonde excavation."*

The specimen, represented Plate XI. Fig. 1, formed a part of Mr. Strange's collection, and was obtained from Switzerland; it bears a very close resemblance to a fossil of Bourguet's, described as Le Cariophylloide à grandes Raies.† Like the preceding fossil, its substance is divided into thick plicæ, rarely ramifying, which are connected together by very slender transverse filaments, very thinly disposed. As in the former fossil, so also in this, a large cavity appears to have existed in its superior part, but which is now filled by the matter of its matrix, which, as well as the substance of the fossil itself, appears to be chiefly calcareous. Possessing only one specimen of this fossil, I was loth to add it to the numbers which I had devoted to the examination of their internal structure. By an examination, however, with a lens, I was enabled to discover that a spongy texture existed in the substance of the plicæ.

Another specimen, of a similar substance and from the same place as the preceding fossil, and, certainly, though not obviously, of the same species, is depicted Plate XI. Fig. 3. In this specimen, the lamellæ are much smaller, they ramify more frequently, and are connected by much more numerous transverse processes, which, as in the preceding fossil, cross the perpendicular lamellæ, nearly at right angles, and thereby frequently form square or rhomboidal interstices. The spongy texture is very distinctly seen, by the aid of a lens, in the lamellæ of this fossil also.

Another elegant variety of this species of fossil alcyonium is shewn Plate XI. Fig. 6. This fossil possesses somewhat of the form of an inverted slender cone, the point of which answers to the pedicle, and the base to the central opening. The surface shews very distinctly, in many

* Monumens des Catastrophes, &c. Tome II. Parte II. P. 50.

† Traité des Petrifications, Planche II. Fig. 16.

parts, the quadrangular spaces mentioned in the preceding fossil, and which are, in this fossil, disposed with a considerable degree of regularity. This fossil is apparently of a similar substance with the two former, and was obtained from Randenberg, near Schafhausen.

A circumstance, particularly deserving your attention, is observable in the three last fossils. In the first, the perpendicular lamellæ are slightly connected by very few transverse processes, and by still fewer ramifications: in the second, the connexion is preserved chiefly by anastomosing ramifications of the lamellæ; and in the last, almost entirely by transversely disposed processes or filaments. This difference is very obvious; and if the two fossils, Fig. 1 and Fig. 6, had only been obtained, no one would have hesitated to have regarded them as distinct species; but in the structure of the one, Fig. 3, so much of the characters of both the former is to be found as necessarily connects them together, and shews that they all are referable to the same species.

Hence you may perceive how little can be done, in the present state of the science, in forming any useful classification of these fossil animal remains; since more opportunities are necessary to empower any one to determine which may be considered as distinct species, and which should be regarded merely as varieties.

The two fossils, which I shall next place before you, will also, I trust, serve to shew the difficulties which I have just spoken of. These fossils, although differing so much in form from the preceding, possess the same kinds of structure which were observable in them: the one being characterized by the connexion between their lamellæ being kept up by inosculation, and the other by the means of interposed transverse processes. Whether these two fossils should be considered as of the same species with the preceding, I will presently endeavour to learn.

These fossils are of that kind which have been generally considered as *fungites*, or petrified sea-mushrooms; nor have there been want-

ing those who have regarded them as the petrified remains of terrestrial mushrooms.

The shape of these bodies approaches so nearly to that of a mushroom, as to fully authorize the name by which they have been generally distinguished by oryctologists. This resemblance has, however, led to an erroneous mode of describing them; every author having, as Mr. Walch has done, in his description of these fossils, considered the convex part as the superior, and the concave as the inferior, as is the case with terrestrial fungi. But analogy teaches us that these bodies grew in a contrary manner; the pedicle, by which they were attached to other bodies, proceeding from the centre of their convex part, and their concavity being, of course, on their superior part.

The fungiform fossil, Plate VIII. Fig. 5, has a considerable concavity on its superior part, and a corresponding convexity on its inferior part. It is formed by tolerably distinct radiating lamellæ, or plicæ, which, passing from the centre to the circumference, are frequently seen to divide, and then again unite; thus forming a species of inosculation. This structure is here shewn on its inferior surface, where the laminæ may be seen concentrating themselves in that part which had been continuous with the pedicle.

On comparing the radiating lamellæ, of which this fossil is composed, with those of the alcyonium depicted Plate XI. Fig. 3, this similarity will be directly perceived. In both these fossils it will be seen that the lamellæ frequently unite, as it were, by inosculation, and are but rarely connected by interposed transverse processes. In this fungiform specimen, this peculiarity of structure, shewn on its inferior surface, is equally evident on its upper surface, which, however, is not here represented; since the general idea of the appearance yielded by the concavity of its superior surface will be sufficiently obtained by the view given of the next fossil.

A very slight examination of the upper surface of this fossil alcyonium, Plate XI. Fig. 7, will be sufficient to enable you to perceive

that, as in its general form it resembles the last fossil, so, in its structure, it is very nearly allied to the fossil represented Plate XI. Fig. 6. In both instances, the perpendicular lamellæ are numerous and small, and the transverse septa or processes very closely set, forming small polygonal interstitial cavities.

A similar fossil is represented in Knorr's elegant work, Vol. II. Plate F 3, Fig. 1. A specimen of the same kind is also figured by Langius,* and is the figure erroneously referred to by Gmelin, as a turbinated medrepore, as mentioned in the seventh chapter of the present volume.

The peculiarity of structure observable in all these fossils seems to lead to the suspicion of their being all varieties of one species. Nor does the difference in their forms make so much against this idea as might at first appear; since, as has been justly observed by Count de Marsilli, the extension of the substance of one species of alcyonium, in very different forms, is a circumstance of frequent occurrence.

With a view to ascertain the nature of the internal structure of these bodies, I obtained a polished transverse section of the pedicle of one, which had somewhat of a ficoidal form, nearly corresponding with the one figured Plate XI. Fig. 3. By this section, the alcyonic spongeous texture was rendered evident, as well as the transverse section of tubuli or small filamentary bodies. The alcyonium was then immersed in diluted muriatic acid, until the whole of the external surface was removed, when it was found that, instead of the perpendicular and horizontal processes, forming regular square interstices, by their mutual decussations, they both appeared, directly on their departing from the surface, to have divaricated and ramified in various sportive contortions, thereby forming a reticular mass, evidently different from the substance of any of the other species, but approaching somewhat to that of the ficoid fossil, a perpendicular section of which is shewn Plate IX. Fig. 12. It is easy to conceive how accordant the structure, which had been here employed, must have proved

* **Historia Lapidum Figuratorum Helvetiæ, Tab. XII. P. 52.**

in securing, by the alternate contraction and relaxation of these tubes or fibres, the repeated efflux and renewal of the sea-water, on which the support of these animals appears to have depended.

To enable me to determine more satisfactorily respecting the structure of these fossils, I devoted two of the fungiform variety to an internal examination. The first of these was very similar to the fossil Plate XI. Fig. 7, but was about a quarter of its size, and had its compartments, resulting from the decussations of the perpendicular and horizontal laminæ, more regularly square. A part of the inferior surface of this fossil being removed, by rubbing down about a quarter of an inch, and the new surface polished, the same disposition to separate into ramifications similar with those which have been just mentioned was rendered very evident. With the hope of obtaining a more distinct view of the mode in which the external laminæ terminated, after ramifying in the manner already described, I placed the other of these specimens in diluted muriatic acid, taking it out and examining it, from time to time, until nearly a quarter of its substance was thus removed. A very unexpected appearance then presented itself; the ramifications, which, even at the least depth below the surface, had assumed a contorted form, were here, at a greater depth, displayed in the most elegant ramifications, bearing somewhat of a plumose appearance, as depicted Plate X. Fig. 13, where the ramifications are magnified to about double their natural size.

In addition to the several forms into which this species has been already seen to pass, I have one, with a reticulated surface, in the form of a bottle: the pedicle forming the neck; and the body, first becoming globose, and then contracting to a narrower base, forming the belly and the stand of the bottle. This fossil, which is a hard and close lime-stone, was obtained from Saumurs, by Mr. Strange, and may be added to the number of curious forms, under which this species of alcyonium is there found.

Plate XI. Fig. 5, is a part of one of the funnel-formed fossils, de-

scribed by Mr. Guettard, as found at Verest and Montrichard. This was selected in preference to a more perfect one, from its plainly shewing the structure of the fossil and the mode of its formation. Its external surface is covered with irregular risings and depressions, and serves, as in the madreporite, Plate VII. Fig. 4, for the basement of the fabric, erected by myriads of hydræ. The tracks in which each has laboured being evident on the broad edge of the fossil, where a fracture, obviously before petrifaction, has well displayed the resulting structure. Even with the naked eye, the little grooves formed by these insects are discernible, and may be traced to the upper surface, which is very closely beset with their terminations in small foramina, with crenulated edges.

In another remarkably fine and perfect specimen of this funnel-formed fossil, obtained by Mr. Strange, from France, the structure is also very manifest. The external ridges and depressions, as well as the internal numerous foramina, are exceedingly distinct, and the grooves, passing across the upper edge of the fossil from the external surface, and opening on the internal, are very numerous and plainly marked. This fossil is of an uncommon size, being seven inches in height, nearly eight inches in its widest diameter, and an inch and a half in thickness. The substance of both these fossils appears to be composed of an intermixture of lime and flint: the solid part of the original body having been silicified, and calcareous matter having filled up the interstices; as has been remarked of several preceding specimens. The alcyonic appearance is, I think, still more evident in another most beautiful fossil, originally of a funnel form, but which has the appearance of having suffered compression, the sides of the cone being brought nearly within half an inch of each other. This was also in Mr. Strange's collection, and marked as having been obtained from Italy. It is about four inches in height, about the same dimensions from one end of the upper part of the flattened cone to the other, and little more than half an inch in its thickness. Its edge, at its

upper part, is exceedingly perfect; and at its lower end, or point, part of its pedicle remains, which appears to have been remarkably small.

Its external surface is marked by very strong alternate risings and depressions passing round it. Its texture, on this surface, appears to have been very close and without any openings, except the very minute foramina resulting from a spongeous texture, so fine as to approach to the membranous, and a few winding openings, apparently the labour of some invading insect. The internal surface differs very much from the external, being so remarkably smooth and regular as to have the appearance of the pile of velvet. On being viewed with a lens, it is seen that the villous appearance is produced by the infinite number of minute openings arranged as close by each other as possible over the whole surface. It is of a light brown, or buff colour, and appears to have much less silex enter into its composition than in that of the two last described fossils. Previously to passing to the consideration of the next fossil, I must call your attention to the obvious difference of structure between these fossils and those which are represented Plate VIII. Fig. 5, and Plate XI. Fig. 7, and which possess somewhat of a similar form. This circumstance is also observable in the fossil we shall next examine.

This fossil, represented in the frontispiece, was found in Wiltshire, and was originally in the collection of the Marquis of Donegal. At its inferior termination, several processes are given off, which, though broken, have much the appearance of the roots of a vegetable: an appearance which is, however, much more similar in another specimen. From the union of these, a narrow and nearly cylindrical neck is formed, which, gradually enlarging, forms a conical cup-like body, the sides of which are about the third of an inch in thickness, but become much thinner at their edge. From the root-like processes several fibres or tubuli originate, which, ramifying, pass along or penetrate the surface, in a direction tending towards its superior part.

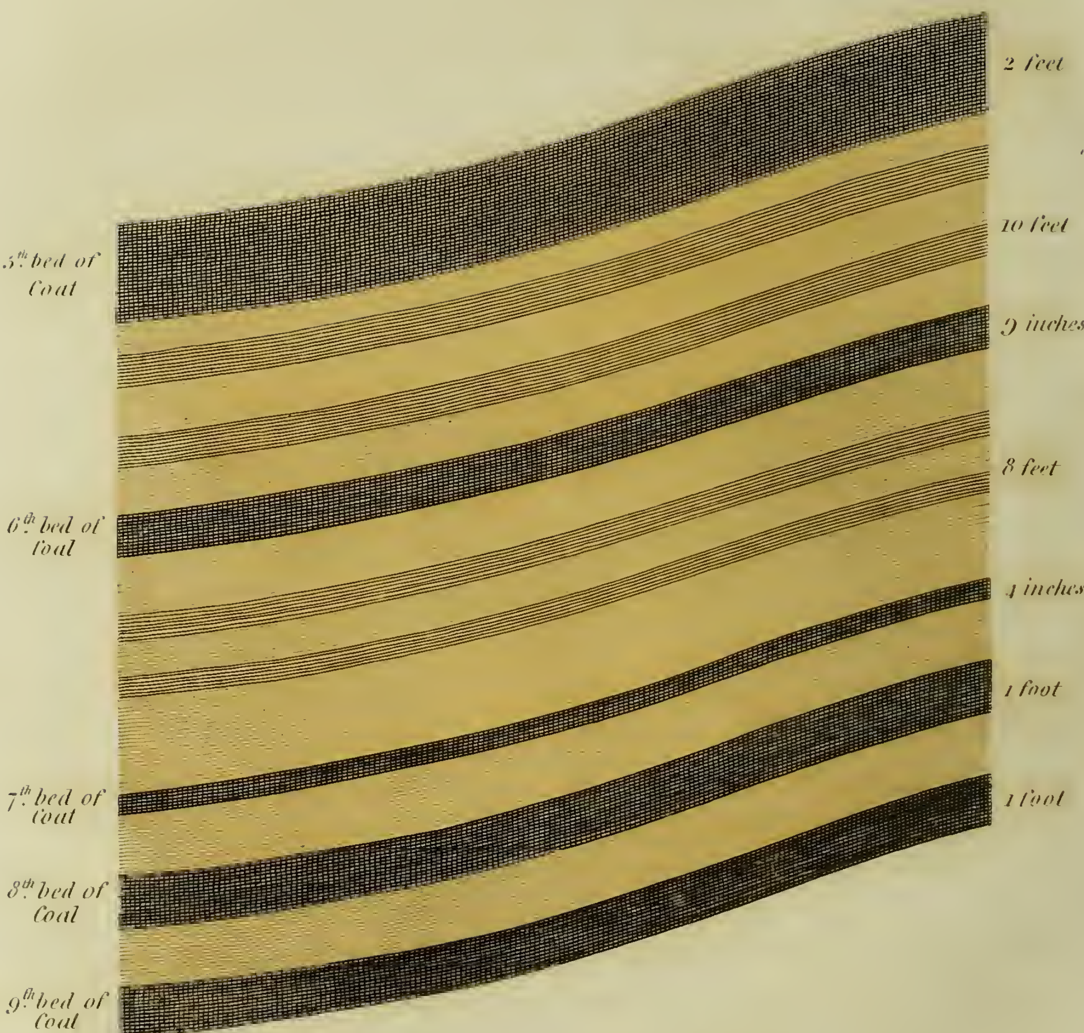
Upon a minute examination of its external surface, a spongeous, or rather porous structure, is discoverable: some of the pores appearing to be the result of a peculiar reticulated texture; whilst others, of rather an oval form, may be supposed to be the openings of the ramifying tubuli, already noticed. The examination of its internal surface is prevented by a friable matter, which appears to be partly calcareous and partly silicious, with which its cavity is nearly filled. A portion of the posterior part is covered with this same matter, which seems to have invested the whole fossil, and appears rather to have been a covering peculiar to the animal than merely the matrix in which it had lain. This fossil resembles, in its composition, several of the French and Swiss alcyonic fossils, already mentioned, in being an intermixture of silicious and calcareous earth: the former having possessed the animal substance itself, and the latter the interstices.

Small fragments of this kind of fossil had been long discovered, whilst digging or ploughing in the Vale of Pewsey: but their forms were so indeterminate and various, as to have led to the most vague and fanciful conjectures respecting their original nature. By some they were imagined to be portions of petrified wood, and by others to be fragments of bones; but Mr. Townsend, who had met with them in his own garden, collected numerous specimens, and in consequence of his extensive knowledge in natural history, soon ascertained their origin, and determined that they were the mineralized remains of some zoophyte of the former world.

According to Mr. Townsend's obliging information, these remains of zoophytes are found immediately under the chalk, in a dark green silicious sand, which contains many prism of quartz crystals; the colour being derived from the intermixture of an oxide of iron. In the same green sand, nautilites are found of a foot or fourteen inches diameter; and on digging deeper, similar bodies to those existing in the green sand are found, approaching to an agatized state.

The farther I advance in my labours, the more reason I find for con-

Section of part of the Strata of Coal &c. at Bovey.



The darkest shade denotes the Strata from which the Coal is procured, the lightest, the argillaceous Strata, & the intermediate, an inferior kind of Coal

Published by M. A. Nattali 1835

gratulating myself on having declined the arduous attempt of adapting a nomenclature to the substances examined in this volume, or of disposing them in a systematic arrangement. Even to one who possessed all the necessary qualifications, success, in the present state of our knowledge, could not be assured. For such is the variety of form and of organization discoverable in these substances, as to mock all endeavours at arranging them, or even comparing them with any known recent substance.

Analogy, indeed, proves their existence to have depended on the powers of animal life, but it seldom helps us any farther; since, with respect to many of them, we can find no corresponding species nor genus under which known existing beings are disposed which will also allow of their admission. New terms must therefore be also required to designate these hitherto unknown substances; but these can neither be formed nor applied, until illustrative specimens and farther observations have supplied a more correct knowledge of these substances, and of the circumstances by which their relationship with each other should be determined.

These observations particularly apply to the fossils which have been treated of in this letter; since considerable difficulty must occur in the endeavour to arrange them, either according to their figure or their external structure. If the fungiform or cup-like figure were to be taken as the distinguishing character, we should then find that under this form would be classed substances, differing very materially in their structure. The fungiform fossil, Plate VIII. Fig. 5, is formed of lamellæ connected with each other by inosculation. The one, Plate XI. Fig. 7, is composed of lamellæ perpendicularly disposed, and so connected by small transverse septa or processes as to produce polygonal terstices. The specimen, Plate XI. Fig. 5, from France, is formed of innumerable tubuli, extending horizontally from the inner to the outer surface; their bases being on the outer, and their other, the open terminations, being on the inner surface. Lastly, the

Wiltshire fossil in the frontispiece, different in its structure from all the rest, is formed of a spongeous substance, which is pervaded and embraced by ramifying tubuli or fibres.

Thus, if the figure of the fossil be assumed as the leading character of the species, substances, differing materially in their structure, will be classed together in the same species; and, on the other hand, if the species be formed on the external structure, we shall have, under the same species, substances differing as widely in their forms as the fossils at Plate XI. Fig. 6 and 7.

LETTER XIV.

ALCYONITES INCLOSED IN FLINTS.....FOUND IN WILTSHIRE, OXFORDSHIRE, BUCKINGHAMSHIRE, AND HERTFORDSHIRE.....OTHER SPECIMENS NOTICED.

It is to my truly learned and respectable friend, the Rev. Mr. Townsend, that I owe the favour of having my attention first called to the fossils, the investigation of which I shall next attempt. That gentleman not only obliged me with a sight of his own beautiful drawings, but also presented me with a specimen of hydrophanous flint, which, with many other more perfect specimens, he had himself found in the Vale of Pewsey. These he shewed me were evidently full of changed organized matter, belonging to some unknown species of zoophyte: of which he pointed out to me not only their internal parts, but even their cortical investments.

These flints were of an oblong, and somewhat of a rounded form; they seeming to differ from the common black flint, in having one of their

surfaces at least, much flatter, and in possessing less of the nodular or mamillary form. Their colour was also materially different; their external surface being generally either of a light reddish brown, or of a greyish white; on which circular or longitudinal patches, of a purplish hue, and possessing more transparency than the other parts, were irregularly disposed. On breaking these flints, the purplish hue and slight degree of transparency, were found, in many places, to pervade the whole substance, whilst in other places they did not enter far beyond the surface. The colour of the interior part of the flint also varied considerably in different specimens, being in some chiefly of a greyish white, and in others of a brown colour, in which a reddish or purplish tinge was discoverable: the more transparent purple patches, already mentioned, were seldom of so dark a hue in their internal, as in their external part.

Slight traces of organization might be discovered with the naked eye, in many parts of these flints, but particularly in the more transparent purplish patches. These were also thus seen to be surrounded with a grey opaque matter, which Mr. Townsend considered as the fleshy or cartilaginous coat, analogous with that which is known to invest the interior harder part, in many coral bodies. On these flints being immersed in water, Mr. Townsend discovered that they were, in a great measure, hydrophanous, and that the traces of organization were thereby rendered much more beautiful and distinct.

Returning, in the autumn of 1807, from a visit to Mr. Townsend, then residing at Bath, I was agreeably surprised to find, that on the road between Henley and Wycombe, and on Wycombe Heath, this kind of flint existed very plenteously, the roads being here repaired with such of them as were ploughed up in the adjoining meadows, or dug out of the neighbouring pits. Proceeding westward along the cross road through Amersham, Cheyness, and Chorley Wood, in Buckinghamshire, to Rickmansworth, a tract of twenty-seven miles,

and thence northerly about five miles to King's Langley, in Hertfordshire, making a tract of road of upwards of thirty miles, I frequently saw, in the road, flints of the same description. But at Watford, five miles southwardly of King's Langley, and three miles east of Rickmansworth, very few of these flints were to be seen: a greyish flint, with a brownish coat, not possessing any organic remains, appearing there to be most prevalent. Aided by the specimens I procured in this route, I was happy on being able to confirm the observations which had been made by Mr. Townsend.

On immersing these flints in water, it may be seen, even without a glass, that the original animal body was composed of an internal, and of an external or cortical part. In the internal part, in consequence of its great degree of transparency, the vesicular or alcyonic structure is very plainly discoverable. In the centre of this part, in some specimens, a ramifying opaque white tube is observable, and at that part which appears to have been the line of union between the internal and the cortical part, fibres or tubules are seen closely placed by each other, appearing to pass, in a converging direction, from the opaque cortical part, towards the centre of the transparent internal substance. Most of these different circumstances are illustrated by the representation of one of these flints from Wycombe Heath, Plate XI. Fig. 4.

Every circumstance which can be ascertained, respecting the animal substances thus inclosed, conspires to confirm the opinion, that they were a species of alcyonium, invested with a cartilaginous or coriaceous covering. Very little to be relied on with respect to the forms which these bodies originally possessed, can be inferred from the different rude sections which are obtained by the fracture of these flints, in different directions. From the figure of the alcyonium which is observable in the flint from Wycombe Heath in Plate XI. and which, in a less perfect form, is frequently seen in the fracture of dif-

ferent flints, I have reason to believe that the cup-like form is the most frequent which a longitudinal fracture of these bodies offers to our view.

That this, however, was not the only form with which these bodies were endued, I obtained a very pleasing proof, immediately on my return to town from the excursion, in which these fossils had so much engaged my attention. The late Mr. Jacob Forster, on leaving this country for Russia and Siberia, nearly about twenty years since, had carefully packed up his private collection of minerals and fossils, not to be opened until his return or death. The latter circumstance having taken place, I availed myself of the opportunity offered me by Mrs. Forster, of purchasing some of the more interesting specimens which that collection contained. Among these was that extraordinarily illustrative specimen which is represented, Plate XI. Fig. 8.

The most ample proof is afforded by this specimen, of the kind of bodies to which this immense number of flints, spread over such a vast tract, owe some of their peculiar appearances. Here the alcyonium, of a similar species with those which are represented, Plate IX. Fig. 4 and 8, with its surrounding cortical part, is seen, permeated with silicious earth, and inclosed in a mass of grey flint. On immersing the specimen in water for a small space of time, the flint, which is hydrophanous in a considerable degree, acquires transparency, and shews the alcyonium itself of a bright red colour, and penetrated by white fibres or tubules; whilst the whole of the surrounding flint is, by the same means, discovered to be very closely filled with a white substance, which is apparently similar to the cartilaginous or cortical part, which immediately invests the alcyonium itself.

I however here experienced some difficulty, since the fossil alcyonium, which I had thus fortunately discovered, did not bear the cup-like form, which appears to be so very prevalent in the flints which had engaged our attention. This difficulty, however, disappeared, on considering, that the cavity, in the superior part of the ficoid fossil

being filled with the grey flint, a longitudinal section, which would pass through that part, would give a cordiform or cyathiform figure, from this dipping of the matter of grey flint, into the middle of the substance of the alcyonium: and if the alcyonium was formed with a broad base, similar to that which is observable in the specimen, Plate IX. Fig. 4, the appearance yielded by its longitudinal section would perfectly accord with the figure of the inclosed fossil, Plate XI. Fig. 4. The colour of this fossil next excited my consideration, doubting how far this instance would authorize the attributing of this colour, even to other alcyonia of the same species; but on looking over my collection of these fossils, I found the detached ficoid fossil, purposely introduced, Plate IX. Fig. 8, which exactly agreed in its form with that which in this specimen is involved in the flint. Not only is the red colour very evident in the body of this detached fossil, but it still retains, over great part of its surface, a thin white covering, apparently the remains of a similar coat, with that which is seen to surround the alcyonium contained in the flint. It is hardly necessary to remark, that the red colour of the animal, blended with the dark semidiaphanous flint, will perfectly account for the purple hue so frequently observable in these specimens.

The flint stone, Plate XII. Fig. 5, found on the sea-shore, at Southend, in Essex, had often engaged my attention. The curious contexture of the plexus of tubuli, of which it is chiefly composed, led me, at first, to suppose it to be a mass of minute serpulæ; this opinion was, however, soon corrected, on discovering, by means of a lens, the frequent inosculations of these tubuli. I became then suspicious of its alcyonic nature; and after having attended to the alcyonic flints just examined, was convinced that it owed its form to a substance of this kind: the circular mark of its original cortical investing matter, yielding the most corroborating proof that this opinion was correct.

Just before the plate which this chapter refers to was engraved, the son of that ingenious artist, Mr. Springsguth, to whose labours this

work is so much indebted, found on the road, in the neighbourhood of Islington, the flint stone, Plate XII. Fig. 10, which will serve, in some measure, to connect these fossils together. On the side may be seen, a little magnified, the external surface of the organized body, formed of similar inosculating tubes, with those which are seen on the surface of the preceding fossil. In the fore-part is seen a section of its internal substance, also a little magnified, in which the marks, occasioned by the various convolutions of these tubuli, are beautifully displayed, being of an opaque grey, whilst the intervening transparent, silicified alcyonic matter is of a strong reddish brown; shewing that the red colour belonged to more than one species of the antediluvian alcyonic genus.

The flint fossil, Plate XII. Fig. 7, found in the gravel at Seward-stone, in Essex, is evidently of the same species with the two preceding fossils. On its superior part, the convoluted tubuli are seen; but its inferior part is quite smooth, and appears like the external coat of the alcyonium. This part is extended in such a form as to give reason to suppose that the alcyonia of this species, like the preceding, were supported by a peduncle.

The flint fossil, Plate XII. Fig. 12, is of very doubtful origin. The confused and indescribable mass in the centre, now perfectly silicious, I suspect, must have been of an alcyonic nature. Flints, distinguishable by the circularly disposed traces observable in the lower part of this specimen, are very frequent.

LETTER XV.

MAESTRICHT FOSSILS.....AMBIGUOUS APPEARANCES.....COMPARED WITH OTHER FOSSILS, FROM SWITZERLAND, ENGLAND, AND AMERICA.

I HAVE, in a former letter, mentioned the fossils of St. Peter's Mounain, and have there proposed to defer the examination of the more minute corals, contained in the masses belonging to that mountain. This I am the more inclined to do, since it would be required, in consequence of their similarity, to take into consideration with them, the *gorgoniæ*, *flustræ*, *and corallinæ*, which are to be found in the Dudley limestone, and which, as well as the others, from their being so minute as to be almost microscopic objects, would require so much time in their examination, and so many delicate engravings, as would have too much protracted the publication of this volume. This objection, however, does not apply to the next subjects of our consideration, which are those Maestricht fossils, which are discernible by the naked eye. These particularly demand our attention, since their peculiar forms and structure, so different from those of other districts, render it exceedingly difficult to determine in what genus the greater part of them should be placed. This consideration, of their differing so widely from the fossils of other parts, is sufficient, I conceive, to warrant their being examined in a separate letter; and the difficulty of determining whether several of them should be arranged among the

madrepores or the alcyonia, seems to render this a fit place for their consideration. An apology is, however, necessary for introducing in this place, among these fossils, one or two which should, perhaps, rather have been placed among the madrepores than among the alcyonia. This has been done, in consequence of my collection of the Maestricht fossils, not having been sufficiently important, at the time I was writing my observations on madrepores, to authorize my speaking of them from my own knowledge. Having since then acquired some very perfect specimens, I have ventured to introduce the examination of them in this place, trusting that their very considerable deviation from the madrepores we have previously seen, and their approximation to the characters of alcyonia; with the difficulties which now oppose similar specimens being brought into this country, may render their admission, although not exactly in their place, not unacceptable.

St. Peter's Mountain, or Pietersberg, is situated within three quarters of an hour's walk of Maestricht, forming an elevated escarpment on one side of the Jaar, and being washed on the other by the Meuse. On the side next to the Meuse, layers of a fine white sand, somewhat chalky, alternate with black, mammillated, and as it were, ramified flints; on some of which the regular organization of madrepores is plainly observable. Shells and wood are also found in this part, impregnated with silex. This circumstance is the more deserving of attention, since the other side of the mountain, next the Jaar, contains, chiefly, madrepores and shells, which are entirely calcareous, and in so perfect a state of preservation, as sometimes to seem, even to possess their original colour.

The zoophytes which are found in the calcareous mass, which forms this part of the mountain, particularly merit our attention. Not only will the beauty of their forms, and the wonderfulness of their structure, engage our interest; but the vast difference observable between them and every other zoophyte of this, and of such as we have seen of the former world, must call forth our utmost astonishment. So

totally do they differ, except, perhaps, in one or two instances, from any other known substance, that although it is sufficiently evident that they are organized masses, which have derived their forms from the energies of animal life; yet, in most of the substances which we shall examine, we shall find ourselves very much at a loss respecting their original nature and the mode of their formation.

The matrix in which these curious substances are found, is a fine tophaceous and pure calcareous substance, deriving a yellow tinge from its impregnation with iron. It breaks, of course, into irregular fragments, an examination of which often shews the traces of various coralline bodies, as well as very small pieces, and sometimes the casts of various shells.

Mr. Walch, who appears to have derived some aid from the inquiries of Mr. Hoffman, Surgeon Major at Maestricht, and who has evidently paid considerable attention himself to these fossils, is of opinion, that they may be divided into three classes. In the first of these classes he places those which are really petrifactions, in which the actual substance of the marine body has acquired a stony nature. In the second class he places those which are merely casts; the lapideous matter, which had filled the several cavities of the coralline bodies, having remained, after the removal of the original substance, by the action of some chemical agent. And, in the third place, he disposes of those, which he considers as merely the impressions of substances which have existed on the surface, or in the substance of these masses, and which have been entirely removed by the action of some menstruum.

Perplexing as we shall hereafter see Mr. Walch found the investigation of these substances, he was yet of opinion, that although there exist among them so many new species of animals, yet he does not see any reason to suppose, that for the arrangement of any of them, the formation of a new genus is necessary. He, however, acknowledges, that he found many bodies which, although he consi-

dered them as alcyonia, he was by no means convinced, that they should be considered as species of that genus, or true alcyonia.

The real petrifactions, Mr. Walch describes, as being chiefly the rete-porites, or fossil flustra; the casts were chiefly of the astroites: and the impressions of the tubulites and fungites. Of the latter he believed but very little of the original substance remained on the Maestricht fossils; he having never succeeded in any of his examinations, which he says were many, in discovering any of the fibrous texture, or of the lamellated part of these bodies; but, on the contrary, he very frequently found that these bodies were formed entirely of the same substance as the matrix itself, and manifested not the least trace of any extraneous matter. It must, however, be here remarked, that Mr. Hoffman, agreeable to the candid acknowledgment of Mr. Walch, did really find, among a great number, two in which he could perceive the opening *(oscula)* proper to these animals. Still, however, Mr. Walch supposes that these fossils, which have acquired their figures from these bodies, have been formed by the filling up of their cavities with earthy matter.

The opinions of Mons. Faujas St. Fond, respecting the origin and the formation of these fossils, correspond very nearly with those of Mr. Walch, excepting that he considers several of these fossils as formed of the changed animal matter, which Mr. Walch supposed to be casts of earthy matter, deposited in the cavities of the original bodies.

I shall now proceed to the unpromising task of inquiring into the original nature of some of these mysterious fossils, commencing with the examination of the fossil, represented Plate XII. Fig. 6. This is a light yellow calcareous stone, on the surface of which arise, at nearly regular distances, though not apparently in any determined order, many small semi-globular, striated, and projecting bodies, which, by the aid of a lens of about an inch focus, are found to be formed of plates, regularly placed round the middle of these bodies;

the central part being filled by the same kind of substance disposed somewhat in a retiform manner, projecting a little beyond the lamellated exterior part. This peculiar structure presents to the eye a floscular appearance, very difficult to describe, but which is very faithfully represented by the magnified figure, Plate XII. Fig. 6, *a*.

By the aid of the lens it is also discovered, that the greater part of the ground on which these bodies are disposed, is adorned by slightly undulating, faint, and minute striæ, which, in some places, appear to unite with, or even proceed from, the plates of which those bodies are formed. So numerous are these waving striæ, and so many are the slight traces of them, as to render it quite fair to suppose that they were originally disposed over the whole surface. Mr. Walch describes this fossil as a tubercular astroites, on a ground marked with delicate striæ; the projecting parts, he thinks, may have been casts of a columnar astroites, and now reduced to a mammillary form.*

In Faujas St. Fond's elegant work on the natural history of the Mountain of St. Petre, in which many of the riches of that immense mine of fossil are displayed, two specimens are depicted, which bear considerable resemblance to the fossil which now demands our attention.

The one figured by Faujas St. Fond, which, in its general appearance, approaches the nearest to our fossil, is to be found Planche XLI. Fig. 1, a. and Fig. 1, b.† This specimen differs from our fossil in two respects: First, the rose-like protuberance are placed with a great deal of regularity, upon lines which appear to form concentric circles round the centre, whilst in those of the fossil figured in this work they are not disposed in any regular order. Secondly, the ground of the fossil described by Faujas St. Fond is very finely granulated; whilst in the fossil here figured, the rose-like stars are placed on a

* Recueil des Monumens, &c. Tome III. Page 163.

† Histoire Naturelle de la Montagne de Saint Pierre de Maestricht, Page 210.

ground enriched by numerous undulating striæ, some of which unite with the rays of which the stars are themselves composed. At Planche XLI. Fig. 6, a. and 6, b, is a fossil which also bears a general resemblance to our fossil, but differs from it in having, instead of undulating lines, superadded rays, which diverge in straight lines from the central star. The fossil, Planche XLI. Fig. 5, which he describes, Astroite mamelloné, avec des rayons en tête de Méduse qui partent de chaque mamelon, would, if reduced to a smaller size, approach much nearer to our fossil than do either of the others.

The specimen, Plate XII. Fig. 4, like the former, is highly interesting, from the difficulties which accompany an inquiry into its original nature; rendered still greater, by the want of any analogous bodies, with which any instructive comparison might be made. This fossil, also obtained from St. Peter's Mountain, is formed of the same substance as the former. The organic part of this fossil is confined to the superior part, and to a small cleft on one side, and is composed of a surface so finely granulated, as to give an appearance like the pile of velvet. On this general surface are disposed, in small depressions, oblong bodies, in an oblique but almost horizontal direction, each body being composed of six similarly formed tubes or fibres, from an eighth to a quarter of an inch in length. Most of these bodies taper a little, at their more detached ends, and thereby obtain somewhat of a conical shape.

A slender fibre branches from about the centre of some of these bodies, and is inserted in the side of the adjoining depression. In some, there are two of these fibrous connecting processes, and in others, no traces of them are observable. But from considering the delicacy of their structure, and their liability to be broken, and observing in that lower stratum, at the one end of the specimen, which has been protected in a considerable degree from injury by the superincumbent layer, that this slender process is attached to every one of these cylindrical bodies, I think there is very little reason to doubt that this

process is essential to this fossil, and that one of them, at least, belongs to each of the cylindrical bodies.

As in the former fossil, so in this, these forms proceeding from the wonderful labours of some lost polypean architect, do not appear to have extended, in the least degree, lower than the surface: the mass of stone being formed, up to the very surface just described, of the same calcareous matters, as in the former fossil.

Mr. Walch considers this fossil as a cast of a tabularia of six columns: he, however, observes, that the tubules from which the casts have been formed, are not here the same as they are in the petrifactions of other countries; for that, instead of these tubes being regularly directed either obliquely upwards, or disposed horizontally, or symmetrically placed at a distance from each other, the tubules, or rather their casts, seem to owe their situation on the surface of the stone to an accidental arrangement. Their form, in Mr. Walch's opinion, shews that they were moulded in striated tubulites, with dentated edges, and longitudinal slight depressions.*

Mons. Faujas St. Fond, speaking of this fossil, which he has figured Plate XXXVI. Fig. 7, of his works, remarks that it is exceedingly perplexing to attempt to class this fossil in a distinct and appropriate place. The extremely minute protuberances on the surface, which, from their regular disposal, give to it an appearance of ermine, he thinks has been, beyond a doubt, the work of polypes;† but in Faujas St. Fond's description of this fossil, no notice is taken of the small lateral processes, which I have described as passing between, and connecting the cylindrical projecting bodies, and the granulated surface. The specimen, which has been here copied, agrees so exactly, in every other respect, with the fossil delineated and described by Faujas St. Fond, as not to leave a doubt of their being

* Recueil des Monumens, &c. Tome III. P. 162.

† Histoire Naturelle de la Montagne de St. Pierre, P. 194.

both of the same species. The absence of these processes in Faujas St. Fond's specimens may, in all probability, have proceeded from their removal by accident; since their extreme delicacy must render them exceedingly liable to injury, and the specimen here figured is remarkable for its excellent state of preservation.

The mass, Plate XII. Fig. 2, from the same mountain, is, in every respect, the most valuable specimen of the kind, which I have yet met with, or have seen described. Since, from having almost escaped from any injury, it not only furnishes us with the correct form of the zoophyte, of which it is composed, but enables us also to make out something respecting the labours of the little animal by which it has been formed.

Fossils, evidently of the same species, are described both by Mr. Walch and by Faujas. St. Fond. The characteristics of these fossils are stellated substances, projecting from a smooth ground. In the fossil described by the former, the stars are composed of seven striated rays; but in the specimen here depicted it will be seen, that they are composed of six rays, standing, some less and some a little more, but in general about an eighth of an inch above the common surface; each of these rays being cordiformed in their transverse section. These rays, as may be seen in the magnified representation of them, Plate XII. Fig. 2 *b*, do not rise exactly vertically; but, having their base more enlarged than their other parts, they bear somewhat of the form of a wheatsheaf. The substance of this, like that of the former fossils from this place, is of a fine-grained calcareous stone, having much of a tophaceous appearance, and bearing a slight yellow tinge. Faujas St. Fond considers this fossil as an astroites; but Mr. Walch believes it to be merely a cast of some coral, the parts which formed its mould having been decomposed, and passed way.

But, in the specimen here depicted, sufficient is discovered to shew, that Mr. Walch is, in this respect, mistaken: parts are here displayed,

too minute, complicated, and delicate, to have been formed in this manner. In consequence of the very perfect state of this specimen, some circumstances in the structure of this zoophyte are discovered, which are not noticed by either Mr. Walch or by Faujas St. Fond, in the specimens which they describe. Whether these amount to specific differences, or are merely accidental varieties, cannot, perhaps, be ascertained, until other illustrative specimens have been compared with these.

The perpendicular lamellæ forming the rays of each star, are closely united to each other, by minute and regularly disposed transverse processes. Innumerable, intercurrent, circular filaments also spread themselves, not only from the top of one of these stars to another, but, in a similar manner, pass even through the bodies of several of these stars, thus connecting all the stellated columns together. The whole of this structure, so different in every respect from the other works of madreporean polypes, is sufficiently inexplicable to excuse the various conjectures which have been made, whilst endeavouring to discover the mode in which this zoophyte originally existed.

On one part of the surface of this fossil, a substance is placed which, at first glance, gives the idea of an enchinite, possessing a rounded form and a mammillated surface. But a close examination of this body gives considerable reason for believing it to be an alcyonium; marks of the stelliform *oscula* of which still appear on the apices of the little mounds, from which it derives its mammillated surface. Several smaller bodies of this kind are also observed, rising up on different parts of the superior surface.

Another description of bodies are also observable on other parts of this superior surface. These are oblong, and somewhat approaching to the fusiform; and from the appearance of delicate traces of stellated figures, I at first conjectured that these bodies were alcyonia, and that these stellated marks were to be considered as the remains of the openings, which are the residences of the polypi peculiar to these

bodies. This opinion, however, was set aside, by a more accurate examination with a lens: it then appearing probable, that these stellular marks had resulted from the adhesion of some of the bases of the stellated columns already described. This opinion was, indeed, almost proved to be correct, by discovering that one of the columnar stellated bodies, which have been described as proceeding from the general surface of the fossil, has been so far lengthened, as to be attached, by its other extremity to the inferior surface of one of these oblong bodies; whilst, in another part, a fragment of one of these stellated columns is seen hanging from this same surface, the other end by which it was connected with the general surface, having been broken away.

What was the original nature of these bodies is exceedingly difficult to determine. At the first glance they excite the idea of similarity with the tophaceous coverings of mytuli, which are sometimes found in the neighbourhood of Bath. Faujas St. Fond, indeed, describes a fossil, Planche XXXVI. Fig. 3, which, though much larger than the body here described, has the same oblong spindle-like form, being gradually contracted towards its base, where it again gently swells out, bearing some resemblance to a large spine of an echinus. The fracture at the base of the fossil described by Faujas St. Fond, decidedly demonstrates that its whole body has been formed by the madreporean polype, whose labours have also adorned its surface with stars elegantly formed, and somewhat resembling the petals of a flower. This fossil is considered, by its ingenious describer, as one of the most singular productions of the whole genus. The fossil body, which is described by Faujas St. Fond, does not, however, exactly agree with that which is discovered on the fossil now under our examination; since, in the latter body, there do not appear any traces of polypean labours, to which its formation can be attributed.

To my worthy and respected fellow-labourer, Dr. Menish, of Chelmsford, I am obliged for the opportunity of having the engraving made, Plate XII. Fig. 1, from a specimen in his collection. This fossil, which is

from a quarry in the neighbourhood of Bath, very much resembles the one described and figured by Faujas St. Fond. The stellular forms on this are, indeed, much smaller than those on the Maestricht fossil, and do not possess so much of a floscular appearance : the general figure of the two fossils are, however, very similar. On one side of the Bath fossil, a crystal of calcareous spar is adherent ; and the fracture at its lower end manifests a slight spathose appearance, in which, however, no traces of organization, similar to those in the Maestricht fossil, are observable. But, to return to the consideration of the general characters of the fossil, Fig. 2, it is worthy of attention in this, as well as in all the preceding Maestricht fossils, that the surfaces of those parts which owe their form to animal organization, have none of the smoothness of surface belonging to corals, but rather the granulated spongeous appearance peculiar to alcyonia. Perhaps this circumstance, certainly of ambiguity, may, in some measure, excuse the placing of these unknown bodies among the alcyonia. Hesitation on this point may appear unnecessary, since I have already remarked, whilst objecting to Mons. Guettard's opinions, respecting the French alcyonites, that they possessed not the stelliform figure which was essential to madrepore. In these fossils, it may be said, that the stelliform figure exists, and that therefore no doubt should be entertained of these substances being madreporean. But it must be considered, that although no coral can be regarded as a madrepore, unless it possess a stelliform structure ; yet it is not every body possessing such a structure that is to be considered as a madrepore.

The fossil, Plate XII. Fig. 9, being a flint from Essex, with which I was kindly presented by Dr. Menish, illustrates this in a very satisfactory manner. The stelliform appearance of this fossil would, at first sight, induce many to place it among theam drepores ; but a careful inspection of it, with a lens of moderate power, proves that it is indubitably a species of alcyonium. When thus examined, it is discovered, that this body possessed none of that hard or osseous sub-

stance belonging to corals, but that it was formed of a substance, whose alcyonic texture is yet to be seen. This body, invested with its highly-coloured cortical substance, as the figure shews, being disposed in deeply indented folds, somewhat like the heraldic nebule, must have possessed, in an eminent degree, the power of enlarging or diminishing the cavity which it formed, by extending, and straightening, or contracting, and corrugating the line in which it was disposed. As has been seen in two or three other instances, the original colour of the animal, being here a reddish brown, has been preserved.

But to return to the Maestricht fossil.—With respect to its stellular columns, and connecting filaments, there can be no difficulty in considering them as constituting a fossil whose form is the most singular, and whose history is the most difficult to make out, of any which have come under our examination. Not only does it differ materially from any known recent zoophyte, but even from any fossil which, in my knowledge, has been discovered in any other part of the world.

In the fossil snbstance which comes next under our examination, insuperable difficulties will, I believe, oppose its arrangement under any existing genus. It is figured in Knorr's elegant work. (Suppl. Tab. VI. Fig. 1.) This fossil has been considered by many as an incrusted millepore; by Mons. Guettard it has been supposed to be a coralline; and by Mr. Walch, who observes that it bears no marks, either externally or internally, of a coralline, it is believed to be an alcyonium. After inspecting the specimen figured Plate XII. Fig. 13, with the utmost care and attention, I was unable to concur with any of the opinions which had been formed respecting this fossil. Upon examining the largest and most distinct branch with lenses of different powers, I was obliged to consider the marks on its surface, as bearing no analogy with those peculiar to the surface of a millepore. Instead of pores, a lens of considerable magnifying power enabled me to discover, that the surface was marked by minute tuberculated lines

closely and spirally disposed. By the same lens I was enabled to trace similar lines, undulating on several parts of the flatter surface; and, in one or two spots, could discover six or eight of these lines, running pretty straight, close and parallel with each other, and connected together by numerous lateral minute fibres or tubuli, giving the appearance of a species of microscopic tubipore, rather than of millepore, madrepore, or alcyonium. A magnified figure of this part of the fossil is presented Plate XII. Fig. 13, *c*.

But were we even capable of determining the genus of this microscopic polypean fabric, still we, perhaps, should thereby make but little progress, in ascertaining the real nature of the large ramose bodies, which seem to bear no other relationship to the minute tubiporean bodies just described, than merely serving as a ground-work, on which they have been formed Of the real nature of the ramose bodies themselves, I must confess myself unable to form a conjecture which seems to make any approach to probability. That they are the remains of some animal substances, formed by the labours of polypes, appears to be indubitable, from the situation in which they are found, and from the bodies with which they are associated; but every character which they possess, differs materially from those of any known substance, which has been marked by the pen or pencil of the natural historian, as deriving its origin from such a source.

On examining the substance of which these several fossils of St. Peter's Mountain are formed, numerous variously figured cavities are observable, evidently formed by shells and other marine bodies, which, having been removed, have left spaces exactly corresponding with the forms which they possessed. It is most probably from this circumstance, that some, especially Mr. Walch, have been led to the suspicion, that the various figured bodies which we have been here examining, have been all casts or impressions of different substances of a coralline nature, which have been involved in the mass, whilst it was in a soft or fluid state; but having been since removed by decomposi-

tion, have left their forms impressed on the mass, which has now assumed a stony hardness. This opinion is, however, contradicted by the appearances which these coralline substances yield, since the most accurate examination proves that these fossils are actually the changed animal bodies themselves, and not merely casts or impressions. It is very true that some difficulty occurs in endeavouring to explain why the shells, &c. should have been removed, and should have left merely their casts and impressions, whilst the whole substance of those coralline bodies and zoophytes have been left, still possessing their particular forms. I at first imagined that this might have been occasioned by the tophaceous mass which involved these bodies having been so impregnated with silex as to resist the action of such agents as might gradually decompose the shells and those other bodies which it had inclosed. This opinion, however, also proved to be totally unfounded, when tried by the touchstone of analysis.

The whole substance of the mass of which these fossils were formed proved to be completely soluble in nitric acid, carbonic acid gas being at the same time liberated in considerable quantity. The addition of sulphuric acid to this solution yielded a copious precipitate of sulphate of lime, which, being separated, ammonia was added to the residual solution, and no precipitate was formed: evaporation, however, yielding a farther deposition of selenite. Hence it appeared that this substance was a very pure carbonate of lime; and although accurate examination has proved the fossils which have been here treated of to be really changed organic substances, nothing in the composition of the mass assists in explaining why the shells, &c. should have been entirely removed, and these fossils have remained, with the rest of the mass, unimpaired.

The Maestricht fossil, which next claims our careful attention, is that which is shewn Plate XII. Fig. 11. It is formed of the same cal-

careous matter, of which the preceding fossils of this district have been found to consist. Two distinct forms are in general to be found on the masses which owe their figures to this zoophyte. The one of these is nearly a hemispherical concavity; a slightly rising, oblong prominence possessing its lower part. The sides of this cavity are formed of knotted or articulated tubes or fibres, which pass, side by side, from its circumference, and terminate at the bottom, in a line, on the oblong prominence, Fig. *d*. The other is a nearly flat, circular space, covered with concentric risings and depressions, and radiating striæ. Fig. 11, *e*.

In the work of Faujas St. Fond, Plate XXXVII. Fig. 8, 9, are given representations of both the forms in which this fossil appears, it being considered by this celebrated philosopher as referable to the *Madrepora Porpita*, Linn. already examined in the commencement of this volume. It is not without due consideration that I venture to differ from such respectable authority, but comparison immediately manifests essential differences between the two fossils: omitting to notice others, it may be sufficient to remark that, in the madrepora porpita, the radiating fibres originate from a point in the centre of the madrepore; but in the fossil now under examination, they terminate in a line which is nearly three-fourths of its length.

I should not, however, have been disposed, I must acknowledge, to separate this fossil from the porpital madreporite so decidedly, had I not also seen reason to believe that it bore a tolerably close resemblance to a zoophyte, which we have already noticed. Indeed it may be adduced as one of the numerous instances in which, for want of a sufficient illustrative specimen, conjectures are formed, possessing almost every appearance of probability, but which, on the discovery of such a specimen, are found to be unfounded and absurd. The fossil with which I conceive this bears so close a resemblance, and which I believe to be actually of the same species with it, is the one which is re-

presented Plate X. Fig. 1, 2, 3, 4, and described in the twelfth letter. The propriety of this opinion we will proceed to ascertain.

On examining the concavity of the Maestricht fossil, *d*, it will be found to correspond very closely with the convex surface of the above fossil, Fig. 4. The structure of the fibres disposed round the concavity of the former, shewn in their representation, as magnified with a lens of but moderate powers, Plate XII. Fig. 11, *f*, agreeing, as nearly as could be expected, with the magnified appearance of the fibres of the former, as represented Plate X. Fig. 3. Considering that the fibres of that fossil are shewn on its external, whereas, in the Maestricht fossil, they are displayed on the internal surface. Sufficient correspondence seems to exist between the two fossils, to manifest the probability, at least, of their having both derived their existence from a similar source. In both are observable fibres passing along the sides, uniting in a line at the superior part of the body, and connected in a similar manner by lateral processes. In a word, in both are seen the same appropriate arrangements, for enabling the animal to adapt its form to the varying circumstances, under which its existence must have been supported.

Should, however, any doubt remain respecting their agreement, it must be removed by viewing the circular impression *e*, on the same mass, which agrees in every respect, especially in its alternate risings and depressions, with the impression which might be expected to be yielded by the inferior part of a small specimen of the fossil depicted Plate X. the inferior surface of which is sketched Fig. 1, of the same plate. Faujas St. Fond gives also a representation of this surface, exactly corresponding in its size with the deep concave impressions. From his figures, the circumstance of these two different appearances proceeding from two different surfaces of the same body, is rendered evident, and is, so far, good evidence of their being the impression of the superior and inferior surfaces of the body to which I have attributed their origin.

Mr. Peale, jun. who exhibited, in the year 1802, in this metropolis, the astonishing skeleton of the Mammoth, found in the state of New York, brought with him a few petrifactions, of which, he observes, an infinite number is found in the neighbourhood of the morasses, from which the remains of that wonderful animal were obtained. Of these, he observes, they are in strange and unknown figures, and appear to be generally marine productions, since various species of coral and sea-urchins were likewise found among them.*

Among the American fossils, which Mr. Peale shewed to me, the only one which appeared to be novel, and particularly interesting, was a piece of dark ferruginous limestone, on which were discoverable the remains of some body, which, although it in some respects resembled the cast of a single-starred madrepore, it essentially differed from it in other respects. About a month afterwards, looking in the shop of Mr. W. Humphries, of Rupert-street, over some specimens which had belonged to Mr. Strange's collection, I fortunately met with a similar piece of limestone, with some very perfect remains of this same fossil.

A careful examination of these shewed that they belonged to a zoophyte, very like to that we have just examined. This fossil is formed of an indeterminate number of lamellæ, perpendicularly disposed, with one edge towards the circumference, and the other in the centre of a semicircular plane. The lamellæ rise, in some of these fossils, in a sugar-loaf form; whilst in others they rather expand at their base, and then suffer a gentle contraction in their diameter, previously to their proceeding to assume a conical form. Around every one of these conical bodies a cavity exists, part of which has necessarily been removed, by the fracture which has exposed them to view. Their form, therefore, cannot be ascertained; their sides, however, may be concluded to be the inner sides of the parietes of a cavity

* Account of the Skeleton of the Mammoth, &c. by R. Peale. P. 39.

belonging to an animal of the genus alcyonium, I do not in the least doubt, nor that the perpendicularly disposed lamellæ are the muscular organs, by which the animal was enabled, as in the fossil just described, to elevate the more central part of its base, and thereby produce that vacuum by which its attachment to any particular body would be secured.

In two several parts of the stone, cavities are also observable, which seem to be the moulds formed on the outer surface of the animal, as the preceding appeared to be formed on the inner. On the inferior surface of these cavities, which are circular, radiating striæ are observable, and which, apparently, answer exactly to the disposition of the inferior part or basis of the lamellæ, already described as forming the projecting part in the cavity of the supposed animal. This flat circular surface, I am therefore disposed to consider as the impression formed by the inferior flat part of the alcyonium, corresponding with the inferior surface of the fossil already described, Plate X. Fig. 1.

Previously to my quitting this tribe of zoophytes, I shall avail myself of the opportunity afforded me by my friend Dr. Menish, of placing before you a very curious fossil from his select and elegant collection. This fossil, which is represented Plate XII. Fig. 3, is chiefly composed, judging from its weight and hardness, of flint, and was found in Essex. It is formed of roundish but rather flat bodies, in the centre of each of which is a small depression. From two of these bodies being, even at present, connected by a small process, and by small protuberances, like the terminations of such processes, appearing on the sides of several of these bodies, there is great reason to suppose that they were all originally thus united. From all these circumstances, I trust that it will not be too much to presume, that this fossil is of the same nature, if not of the same species, with those which are represented Plate VIII. Fig. 10.

The almost transparent chalcedonic alcyonite, from France, Plate

XII. Fig. 8, is an interesting fossil; terminating, at the lower end, in a point, from which the pedicle proceeded, and having in its superior part, the opening into its larger cavity, and on its sides the numerous openings, in which its peculiar hydræ had their residence.

I must once more observe, before I quit the fossils of this family, that I have, in several instances, classed as *alcyonia*, bodies, which appear, in some respects, rather to accord with the genus *doris*, *ascidia*, or *actinia;* but which, in their general characters, differ so widely from any of these bodies with which we are at present acquainted, as to prevent their being placed under any existing genus. Here, perhaps, they had better remain, until more illustrative specimens shew their real nature, and the genus to which they more properly belong.

LETTER XVI.

ENCRINITES AND PENTACRINITES.....TROCHITES.....HISTORY OF...... VARIOUS SPECIES DESCRIBED......ORIGINAL ANIMAL MEMBRANE DEMONSTRATED....SCREW-STONE.

We shall now proceed to the examination of a series of animals, which, whether we consider their extraordinary forms, the immense numbers in which they must have existed, in a living state, in the former world; or their being now, except in a solitary instance or two, to be traced only by their petrified remains, under the surface of the earth, or on the summits of mountains, undoubtedly offer to us as rich a field of observation as the most arduous inquirer could wish to explore.

Differing essentially in their characters from every other zoophyte, either fossil or recent, their examination, if pursued with even a moderate portion of success, cannot fail to excite a high degree of interest. It must, however, be remarked, that these circumstances, which are supposed to render the investigation so interesting, are necessarily such as also tend to render it more difficult. The want of analagous appearances in other substances, either recent or fossil, must necessarily much impede the progress of the naturalist, who is endeavouring to ascertain the original forms of these animals, by putting together fragments, which have now actually become subjects of the mineral kingdom; and which were separated and dispersed before the existence of the present world. Still greater will be the difficulty which must accompany the attempt to obtain some correct notions respecting the various habitudes, and the different modes of existence of these animals from materials so imperfect.

These bodies are separated from all the other zoophytes by this distinguishing character—*their trunks and limbs are formed of bones articulated with each other by surfaces, marked with a floriform or stelliform figure.* From the external forms of these bones, a natural division of these animals into two sections, or perhaps genera, takes place: those, the bones of which have almost all a circular or oval circumference, have been hitherto termed Encrinites; and those, whose bones nearly all possess a pentagonal circumference, have been distinguished by the term Pentacrinites.

Many of the terms which are at present applied to the respective parts of these animals are undoubtedly objectionable. This is, indeed, a circumstance which might with reason be expected, since these names were given to the several parts soon after their first discovery; before any just notion could be formed respecting their real nature, or the relationship which existed between them. A fancied resemblance to some known figure was generally, therefore, the capricious circumstance on which their appellation depended, as may be per-

ceived, in the various terms which have been employed to designate the smaller parts of the animal; such as asteriæ, trochitæ, &c.

Whilst seeking more appropriate names, I shall employ the same delicacy, as is demanded on any other occasion, of interfering with accepted terms: I shall endeavour to obtain such names as are fitted to the parts of an animal, with as little change as possible of the terms now in use; many of which having been derived from the vegetable kingdom must, however, of necessity, undergo alteration.

Whilst thus endeavouring to adapt proper names to the respective parts of these animals, it will be proper to take a view at the same time of the uses of those parts; since it is hoped that we may thereby be led to the adoption of such terms as may be employed with most propriety for their designation.

Several bodies have been discovered, which, from their form, the manner in which they are disposed, and from various other circumstances, have been considered as the inferior terminating, or radical part of these animals. These it seems proper to regard as the *inferior extremities* of the animal; but whether these existed in a loose floating state, furnishing the animal with the means of merely temporary attachment, and voluntary removal; or whether they served, like the extended and flattened bases of the *Gorgonæ*, to fix the animal immoveably to one particular spot, cannot, perhaps, be known: the determination of this question will not, however, affect the name here intended to be employed. PEDICLE, or *Astropodium*, long used by oryctologists, appears to be generally applicable to such substances. *Astropodium*, implying the pedicle of a star-shaped animal, is undoubtedly very proper, in some particular instances; but the word pedicle appears to be preferable, on account of its being more capable of general application.

Instead of the term *stalk*, so generally used with reference to the stem of the stone lily, we shall adopt that of TRUNK: and with respect to its component parts, so long known by the names *Trochitæ*

Entrochi, and *Asteriæ*, I shall consider them, and shall most commonly speak of them, as VERTEBRÆ, joined or disjoined; and pentagonal or cylindrical; and instead of *stirts* or *wires*, we shall mark the processes which go off laterally from the trunk, by the terms VERTEBRAL APPENDICES or PROCESSES.

The basin formed at the superior part of the trunk, by that which is termed the *pentagonal base* by Rosinus, and in which there is every reason to suppose that the organs for the reception and the digestion of aliment were placed, I shall term the PELVIS: and the substances, by which it is formed I shall consider as RIBS, CLAVICLES, and SCAPULÆ. The articulated parts, not longitudinally divided, proceeding from these, I shall consider as the ARMS; when divided, the HANDS formed of fingers; and the innumerable, articulated appendices, proceeding from these, the TENTACULA. The remains of the vertebral column of these animals are so numerous, and at the same time so varying in their forms; and, in consequence of their being seldom found united to the other parts of the animal, can so rarely be classed, with any certainty, with the species to which they belong, that it appears to be advisable to examine them first generally, and afterwards to point out, as nearly as may be, those which belong to the several species of this animal which may fall under our observation.

Small stony bodies of a circular form, some very thin, others cylindrical, and others almost orbicular, marked on their flat surfaces, with minute striæ; and on their margins, with small indentations and projections, have been long found in the earth, in different parts of the world, and have acquired different names, according to the whims and caprice of the vulgar. In Germany, they have been named *Spangensteines*, from their likeness to the beads of a necklace; and *Roedersteines*, from their rays passing from the centre to the circumference like the spokes of a wheel. In Upper Saxony, they are known by the appellation of *Bonifacius Pfenninge*, or St. Bonifacius's money; they

being found in great plenty on a mountain near Günserode, in the neighbourhood of Frankenhausen; which mountain obtains its name from St. Boniface, the tutelar saint of the Thuringians. The Westphalians have also called them *Hünuthrænens;* the vulgar having considered them as the petrified tears of giants. Those which have acquired a degree of thickness beyond some others, have been named *Lapides caseiformes*, from their cheese-like shape; or *Muhlsteines*, from their supposed resemblance to a mill-stone in miniature: and those whose length rather exceeds their width, have been termed *Modioli lapidei*, from their bearing in miniature the shape of a bushel measure. When their sides were tumid or convex, they were, from their cask shape, called *Caditæ*, *Volvolæ doliatæ*, and *Volvolæ utriculatæ;* and from their surface bearing a resemblance to a wheel, they have been termed *Rotulæ lapideæ.*

In some parts of England, they are called *Fairy-stones;* and in others, *St. Cuthbert's beads*, owing to their central foramen allowing them to be strung like the beads of a rosary; but the general term by which they are known by the admirers of fossils, is that of Trochites. When conjoined together by their flat surfaces, in a columnar form, the series is termed Entrochus.

Agricola* speaks of *trochitæ*, *lapides judaicæ*, and similar stones being found in the fissures of the spotted, and of the whitish ash-coloured marble. Because, he says, this kind of marble being wetted, the water filters, so that such stones are formed by that which separates from it. But because marble is for the most part hard, and but little is separated from it by the water, these stones, therefore, are but small, and are frequently forced out of these fissures by the force of the water.†

Not only the names and the descriptions, but this opinion, of Agricola, respecting the formation of these fossils, were long adopted by

* De Natura Fossilum, P. 256. † De Ortu et Causis Subterr. Lib. IV. P. 513.

succeeding mineralogists. Lhwydd, however, in his letter to Dr. Richardson, in 1698, offers some very rational opinions respecting the origin of these bodies: having, as he observes, suspected that every species of entrochus had proceeded from some kind of sea-star, he was induced, supported by the arguments contained in this letter, to positively assert that to be the fact which before he had only suspected. He also contributed much to promote the knowledge of these bodies, by the figures of them which he annexed to his work. Lachmiund had, however, preceded him in this respect; having given a series of figures, in which he had marked several of the peculiarities of both trochitæ and of entrochi. The opinion of Lhwydd was adopted by Langius, Scheuchzer, and others; whilst Charleton, Mylius, Leibnitz, and especially Buttner, who had so zealously contended with Woodward, against the mineral original of fossil corals, were also convinced of the animal origin of these bodies; although they did not pretend to determine to what kind of animal they had belonged.

Hellwing, although aware that Mylius had referred the trochitæ, &c. to the animal kingdom, and that Lhwydd had imagined them to have belonged to some species of the sea-star, formed the opinion that they were rather referrible to the fossil corals; and, of course, considered these bodies, with the corals, as belonging to the vegetable kingdom. Lesser, in his work entitled Litho-theology, as well as Harenberg, who had paid very considerable attention to this species of fossil, were also satisfied of their vegetable origin.

To this opinion of their vegetable origin, our celebrated countrymen, Ray and Lister, agreed: they, however, contributed considerably to increase the knowledge respecting them, by collecting and comparing various specimens. In this work they were much assisted by Mr. Beaumont, by whose industry several very valuable remains of these animals were collected. I shall here introduce the opinion of this gentleman respecting their original nature, since it will serve

to evince how little information on this point had been obtained at that period.

" The main consideration concerning these figured stones, which I call *rock plants*, is, whether they are parts of plants or animals petrified, or *lapides sui generis*, to which latter opinion I incline. Indeed, the figured roots, on which these rock plants sometimes grow, (as appears by the impressions of rays on their tops, answering to those in the joints of the plants, and by the impressions of oval joints there,) may give us some suspicion that they once belonged to an animal, whether it were a species of the *stella arborescens*, or some other; but those trunks of stone plants (entrochi) cannot be looked upon as parts of animals, with the least show of probability; and I think them almost as hardly reducible to any known species of vegetables."*

But it would be, indeed, endless to enumerate the various conjectures, which have been formed respecting these bodies; by some, they were supposed to be the vertebræ of some species of cartilaginous fish; by others, they were concluded to be mere capricious forms of a sportive creation.

It remained for the intelligent and indefatigable Rosinus, to supply us with accurate information respecting these bodies; and to place before us a correct sketch of their numerous species. Aided by his labours, by the remarks of Mr. Walch, and by those specimens which I may happen to possess, I shall now place before you an account of such of these bodies as appear to me to be most necessary to be particularly noticed.

The Trochitæ *are spathose circular stones, of different thicknesses, with flat, concave, or convex surfaces, with various markings, and pierced with a central hole.* These we may divide into those, the central hole of which is circular; and those in which the central hole is polygonal; and then may distinguish them again by the markings on their

* Philosophical Transactions, Vol. XIII. P. 277.

broader surfaces. Trochitæ, with a circular hole, may be divided into the following species:

The first species has striæ passing nearly straight, from the centre to the circumference. This trochites, or vertebra, is figured and described by Rosinus, Tab. VII. Cap. III. Class A. 1, 2, 3,* and is here represented Plate XIII. Fig. 13. The striæ of this trochites appear, to the naked eye, to pass straight and undivided to the circumference; but it may be discovered, by the aid of a magnifying glass, that the rays are not arranged exactly as might be expected, the same striæ not being continued all the way, but, in some places, apparently ramifying; and in others, having fresh striæ superadded in the intervals, towards the margin, to supply the vacancies which would necessarily be left by the diverging of straight rays, passing from the centre to the circumference. A sketch of the manner in which the rays of this trochites are disposed is given Plate XIII. Fig. 14, as taken by the aid of a lens.

On viewing these trochitæ, when united together in the entrochus, or vertebral column, with the aid of a strong magnifier, the articulation will be seen to result from the reciprocal reception of the eminences of one of these bodies into the depressions of the other. This observation is applicable to the articulations of entrochi in general.

The second species of this kind, Fig. 16, has its exceedingly fine rays passing directly from the centre to the circumference, and disposed, on the one side, on a concave, and on the other, on a corresponding convex surface. It is figured by Rosinus, Tab. VII. Cap. VIII. B. 2.†

Possessing but one specimen of this trochites, I am unable to ascertain the figure of the entrochus, into the formation of which it enters. Neither is its entrochus noticed by Rosinus: but as the sides

* Tentaminis de Lithozois ac Lithophylis Prodromus, P. 64.

† Tentaminis de Lithozois, P. 70.

of the trochites are rounded, the sides of the entrochus must necessarily be formed in alternate round ridges and depressions.

The third species, Fig. 15, has its opening in the centre of a depressed area, the broad-raised margin surrounding which is radiated with fine striæ, like the former. This trochites is noticed by Rosinus, Tab. VII. Cap. III. A. 3.

The fourth species, Fig. 11, has a flat, smooth, central surface, surrounded by a crenated margin, and is of a cylindrical form. Trochitæ of this species are figured by Rosinus, Tab. VII. Cap. I. A. 1, 2. 3, 4; Cap. II. A. 1, 2, 3, 5, 6. The entrochi belonging to this species, Fig. 1 and 2, assume different forms dependent on the shape of the sides of the trochitæ, of which they are composed; the trochitæ in the one, Fig. 1, being gently depressed in the middle part; whilst in the other, Fig. 2, they possess a small degree of convexity; the articulating surface in each specimen being formed by a smooth central surface, with a crenated margin. Fig. 12 represents one of this species, which has a smooth central surface surrounded by a deeply crenated margin; the radiating eminences being so broad and so rounded off, as to bear somewhat of the appearance of a folded leaf. Rosinus describes several trochitæ which have a similar appearance. The corresponding entrochus, as might be expected from the size of the marginal notches, is characterized by the greater width and roundness of the identations and markings at the articulation. Rosinus describes another trochites, in which a circle is interposed between the central hole and the crenated margin. He also describes another trochites of a singular kind, having the two sides unequally marked; eleven rays being observable on the margin of one side, and fifteen on that of the other. The trochites, Fig. 17, which I consider as the fifth species, has rays of a curious structure. Concentric depressed circles, closely set, repeatedly divide each ray into several parts. The surfaces, therefore, are covered with small protuberances, regu-

larly disposed in concentric circles, and, at the same time, in rays, converging from the circumference to the centre.

The numerous different markings of figures, observable on the flat surfaces of the trochitæ, shew what various means nature sometimes employs to produce a similar effect: thus increasing the beauty of her productions, by an unceasing variety of forms. In no instance, hardly, is this sportive luxuriance more evident, than in the entrochite, Fig. 18. It is there seen, that the striæ are more thickly disposed in some places than in others. Some of these striæ pass directly from the centre to the circumference; others pass through only half that space. Some are undivided, whilst others are bifurcated; the whole forming a surface singularly beautiful in its appearance, and well fitted for the office for which it was formed. This trochites is represented nearly double its size, that the disposition of its striæ may be better seen.

The sixth species, Fig. 33, is rather uncommon; it is beautifully marked over the whole of each surface, with undulating and ramifying ridges and correspondent depressions, elegantly disposed from the centre to the margin, where they terminate in exactly regular distances. This trochites is represented of twice its natural size, the better to shew the curious forms on its articular surface.

The eighth species of trochites, Fig. 19, I believe also to be rare. It is perfectly circular; and from its circular central foramen proceed five phylloidal rays, which terminate in equal distances, in a narrow crenated margin.

The trochitæ with a stellated central foramen, as well as those with a circular foramen, may be divided into several species. The first of these, Fig. 20, is closely beset with very fine striæ, passing directly from the centre to the circumference, in a similar manner with those of the trochites, Fig. 13. The central foramen of all the following specimens are pentagonal, except where otherwise described. In the second spe-

cies, the central opening is in a smooth concave surface, which is surrounded by a finely crenated narrow margin, as is shewn in Fig. 21.

In the third species, the opening is in the centre of a circular, depressed, central surface, which is surrounded by a broad, raised, and finely crenated margin, as delineated in Fig. 22. No representations are given of the entrochi which are formed by these three species of trochitæ, since, as their margins are similar, no difference can be observable in their articulations, when viewed externally: for similar reasons the figures of several of the entrochi are omitted.

The fourth species, Fig. 23, is of a very curious structure. Its five-rayed opening is surrounded by a small finely striated circular area, around which is a smooth circular groove, surrounded by a raised marginal ridge, the upper and inner part of which is finely crenated.

The corresponding trochites with the last appears to be the one represented Fig. 25, the body of which bulges out considerably, and its articulating surface, which is formed of a smooth area round the central opening, surrounded by a margin crenated on its outer part, is exactly fitted to be received into that of the former trochites, and to constitute a series, such as is represented Fig. 44.

The most common form of the stellated opening is that with five rays. There are deviations, however, from this form, as in the trochites Fig. 26, where the central foramen has three obtuse rays, from which proceed minute striæ, which pass directly to the margin.

By different arrangements of trochitæ, varying like those represented Fig. 23 and 25, in their size and form, entrochi of different figures are obtained, as are instanced in Figures 5, 6, 8, 42, 43, and 44. The specimen Fig. 8, which is a little bent towards its upper part, is particularly interesting, since it serves to demonstrate that this peculiarity of form is particularly fitted for those entrochi which form that part of the trunk of the animal which is nearest to its head. But this circumstance will be particularly attended to, when inquiring into the uses of these parts.

In several trochitæ, projecting points are observable on their sides: some of these appear to have been intended chiefly for ornament: such appear to be the five regularly disposed processes on the trochites at Fig. 27, which, from their regular position, almost give to the trochites a pentagonal form. The entrochus, Fig. 7, is of a very peculiar form. It is composed of plain trochitæ, alternating with sharp-ridged and with knobbed trochitæ of a larger diameter. This specimen is not in that state of perfection to allow of its being determined, whether or not the knobbed processes have served the purpose of articulation with any other bodies, which have gone off laterally; a circumstance which is rendered very probable, by the regularity of their form and disposition. It is to trochitæ of this species that Mons. Davila gives the name of *Trochites epineuses*, and to the minuter points of which Rosinus applies the term *Aculei minimi*.

The entrochi, Fig. 4, 9, 45, 46, have also lateral processes. In these sufficient marks are discoverable by which it may be determined that these have been certainly for the purpose of articulation. Thus, for instance, by the aid of the lens, it is discovered that the lateral process of the trochites, Fig. 4, is not only a regular concavity, with a crenated margin, but that there is also, in the middle of the cavity, a small canal, which pierces through the body of the trochites, and passes into the common central cavity of the chain of trochites, or spinal canal. By this is shewn, not merely that this was an articulating surface, but that a due communication was here also preserved with the general organ of sense and of motion.

Fig. 45 represents an entrochus which is very interesting. On the uppermost of the trochitæ which compose it, three of these articulating processes are observable: a minute trochites is also discoverable on two of these processes, being the first of the new or second series of trochitæ.

The distorted column, Fig. 9, presents us with a set of trochitæ which are ornamented by small projections on their sides. These

have evidently been intended for the purpose of articulation; since, on two of these trochitæ, a real crenated articulating surface is observable.

Fig. 28 represents a single trochites, on one side of which is a circular, concave, articulating surface, with a crenated edge and a central foramen.

Entrochi are sometimes formed of trochitæ, which are smaller at one end than at the other; and the trochitæ being adapted to each other, by the small end of the larger being attached to the larger end of the next trochites in size, the entrochus itself bears a conical form. Other varieties are observable in the forms, both of trochitæ and of entrochi, which will be noticed as they occur.

There is, however, one species of trochites which may be noticed in this place. This species is chiefly found, it appears, in Somersetshire: it is of an oval form, with a central foramen, from which, towards each end of the trochites, passes a slight ridge, and in others a small groove. The following account of this fossil, given by Mr. Beaumont, jun. of Stony Easton, in Somersetshire, appears to be so very accurate as to claim being introduced here in his own words.*

" Mr. Lister mentions one trochite he found, of an oval figure, the rays scarcely apparent, and a very small point in the place of the pith. I have of this species, with *entrochi* the same, (if these, having lost the figure, may retain the name of τρόχος;) some of them have good large holes in the middle, like other trochites; but their bore is oval, according to the stone. I have many other trochites of this kind, but with this difference, that these have no rays, but are joined together only by one ridge, which passes directly along the middle of the stone, the long way, there being a furrow in the other answering to it; these have also a small peck in the middle, making but very little impression in the stone, and seldom passing through it, though I have

* Philos. Transact. Vol. XI. P. 727.

of this sort with indifferent holes as the other trochites, but such are commonly pointed at their ends, and not carried out with an oval round as the others. There are some single joints, which are shaped with a double oval, that is, the oval in the upper part of them stands clean contrary to the oval in their lower part. In some again, the ovals do not stand extremely opposite to each other, but only the oval in the upper part of the trochite seems a little wrested from the direct line of the oval in the lower part, so that they stand bend-ways to each other, like a St. Andrew's cross; and there are entrochi made up after this manner; and I find most of the oval entrochi grow crooked and twisting. There are of these oval kinds of all degrees of thickness and thinness in their joints, as are found in the round ones, and so for the bigness of their circumference, their smoothness in their outward circle, and their roughness with ridges, knots, and branches, the length of the *entrochi*, their injuries, &c." The specimens delineated at Fig. 32, 40, and 41, will illustrate the foregoing remarks.

I believe the difference of colour, observable in different trochitæ, almost always depends on the nature and quantity of any impregnation with which they may have been pervaded, whilst acquiring a lapideous state. Their general colour is white; but from different degrees of ferruginous impregnations, they pass from a yellowish white to a pretty full yellow colour. They are also sometimes of a greyish blue; and, according to M. Schulz, of a greenish colour. One species in particular, I have frequently seen of a reddish brown, and Mr. Walch speaks of some as being sometimes of a pale red. With respect to these Mr. Walch remarks that, when they possess a red tinge, which their matrix does not partake of, we may have some right to suspect that it may be the remains of the colour of the recent animal; since, he observes, there are jointed sea-stars of a red colour: in this opinion I am disposed to concur, from what I have observed in one particular mass of these substances. Mr. Walch, however, will

not allow that a similar inference should be made in favour of those which are of a green colour; although the recent *Palmier Marin* of M. Guettard was of a green colour; since the other petrifactions from Plauen, whence the green trochitæ have been obtained, are many of them of the same colour, and evidently from an impregnation with copper.

Upon exposing the external parts of entrochi, &c. to the action of weak acids, I had repeatedly observed that, on handling them, they yielded a slippery feel; and was thence led to conjecture that, besides the investing matter so evidently observable about the inferior extremities of encrinites, a membranous covering might have been spread externally over the whole of the vertebral column, limbs, &c. of these animals.

With the hope of obtaining some information on this subject, I therefore suspended an entrochus, consisting of two trochites similar to that which is depicted Plate XIII. Fig. 12, during twelve hours in vinegar. Upon examining this, it was found to be reduced to nearly half its size: the remaining fragment being perfectly smooth, and free from any adhering matter. Suspecting that the acid had acted with too much force, I suspended a similar entrochite, formed of two trochites, in two ounces of water, to which ten drops of muriatic acid had been added. On examining this, after twenty-four hours, I found several membranous flocculæ adhering to its sides, and on attempting to remove it, for the sake of obtaining a closer inspection of it, the bottle, by accident, suffered a sudden jar, and immediately a fine transparent membrane separated from about three-fourths of the inferior surface of the trochite, and hung suspended from it in the fluid; bearing every mark of that surface, and most particularly of its crenated edge. A faithful representation of the appearance of this preparation, which was preserved two or three months, is given Plate XIII. Fig. 47. Thus was afforded another instance of the curious fact of the extrication of an animal membrane from a mass of stone, in which it

had been imbedded, and with the particles of which it had been pervaded for several thousand years.

Rosinus, having remarked the separation of several laminæ from fossil shells, each preserving the regular form of the shell: and having also observed in several circular asteriæ, which had undergone a considerable degree of decomposition, that one layer separated after another: and that, although the size of the stone became thus diminished, the figure, which it had before possessed, was still preserved, he was led more closely to examine into their internal structure. For this purpose he rubbed down several asteriæ on a proper stone, and found, that although he thus reduced their size, yet the same figure which had adorned their surfaces was still discoverable, when the new surface was brought up to a polish. This circumstance though most easily demonstrated, in pentaphylloid asteriæ, is, he observes, although not so constantly, nor so easily, also demonstrable in the other asteriæ.

From this circumstance he infers that the increase of these bodies must have taken place, by the regular apposition of new matter on the original figured surface; and that hence the original figure is found to pervade through the whole substance.* M. Walch, however, contends that Rosinus is here mistaken, and asserts, that the markings on the horizontal surfaces of these bodies are but superficial, and should be considered as so many apophyses.†

To enable me to form a just opinion on this point, I rubbed down several trochites and asteriæ, and was thereby satisfied, that neither the star nor the flower passes through the whole substance, but, on the contrary, that, in by far the greatest part, they are not discoverable at all beyond the surface. In that species of asteriæ, whose circumference is nearly circular; and this species Rosinus describes as ex-

* De Lithozois, P. 9.

† Recueil des Monumens des Catastrophes, &c. Tom. II. P. 67.

hibiting appearances most agreeable to his opinion, this circumstance appears to be more difficultly ascertained. The figures are here strongly relieved from the surface on each side, these forming the chief thickness of the stone, so that whilst rubbing these down, if much care be not taken by frequent examination, the intervening space is soon passed through, and the figure on the other side becomes gradually displayed. To make this examination with most success, the asteria should be rubbed down obliquely; and then, on that part where it is most rubbed down, the figure will be found first to disappear, and an opportunity will thus be given, by which the intervening substance between the two stars may be discovered.

This circumstance appears, however, to be completely decided by the agency of the muriatic acid in the preceding experiment, since, upon the separation of the crenated membrane, on which had been deposited the earth, forming that which we may, with Mr. Walch, consider as an apophysis, or rather as the cartilaginous medium for articulation, the acid was allowed to continue its action: and the surface from which this apophysis had separated, being then examined, was found perfectly plain.

One of the ossiculæ of this animal, which I have considered as the ribs, was also exposed to the action of the muriatic acid in a very diluted state. In this instance, as in the former, as the calcareous earth was removed by the muriatic acid, numerous membranous flocculæ were very distinctly observed, depending from various parts of the fossil.

The fossil Plate XIII. Fig. 10, known in this country by the ill-applied term of Screw-stone, and called by the French *Vis Depressoir*, is a cylindrical column, composed of lenticular disks marked with fine radiating striæ, attached to each other at the centre. The edges of these disks are, of course, from the apposition of two convex surfaces, separated at some distance from each other; considerable difference, however, is observable, in this respect, in different specimens. The

convexity is sometimes so trifling, that the edges very nearly approximate. In this case, the disks necessarily exceed in number those which fill the same space, but whose convexity, and, of course, whose central thickness is more considerable. The size of the disks is not always the same, even in the same column; nor is the shaft with which they are united always of the same form, it being in some circular, and in others, pentagonal or stelliform. A variety of appearances also are observable in these fossils, dependent on the absence of the shaft, or the absence of the whole or a part of the disks. The size of the columns, and of course, of the cavity in the stone in which they are contained, varies from the eighth of an inch to nearly two inches in width; the size of the cavity in which the column is contained, it must be, however, remarked, always exceeds, and sometimes very considerably so, the size of the column. The number of disks in a column is also very various: sometimes not exceeding three or four, and at other times amounting to upwards of thirty. The ends of the several cavities containing these columns are striated, in the same manner as the disks themselves, and have the columns attached to their centres; the vestiges of the broken shaft being observable, when the column has, by accidental injury, been removed. The sides of these cavities are also marked by concentric rings, which, as has been observed of the disks, are, in some specimens, disposed much more closely together than in others. On the sides of these cavities, and between these rings, very small projections and depressions are also sometimes observable. The substance of which these stones are formed have generally been supposed to be of a silicious nature, but Mr. Walch supposes them to be a hard and compact star; acknowledging, however, that those specimens which are obtained from Huttenrode are of a hardness nearly equal to quartz: a circumstance which he attributes to the ferruginous particles with which they are penetrated. They are most commonly of a deep brown colour; evi-

dently from the introduction of a considerable proportion of carbonate or oxide of iron into their composition. Those which are obtained from Blackenburg are generally of a deeper colour than those which we find in England.

The nature of these bodies was, for a long time, entirely unknown. In 1751, M. Lieberoth, of Hettstedt, published an essay on the origin of these substances in the Hamburgh Magazine, in which he endeavoured to prove that these cylindrical bodies were the remains of some totally unknown animals, which, like the earth-worm, had the power of contracting and of elongating themselves. This opinion was opposed by M. Lehman, who contended that these stones owed their peculiar forms to the rays of the Caput Medusæ, impregnated with iron. M. Vogel hazarded a conjecture that these forms might arise from particular species of strombites. A satisfactory explanation of the origin of these bodies was first given by M. Schulz, who attributed their formation to the introduction and deposition of an ochrous matter in the cavities of entrochi.

Whoever will take the pains to examine the internal structure, and the cavities existing in the vertebral column of the encrinite, and will also attentively view the screw-stone, cannot but perceive, how exactly the cavities of the one correspond with the projecting parts of the other; and how certain it is that the screw-stone is the cast of the internal part of this column.

But little difficulty will, I believe, occur in explaining the manner in which this cast is formed. These columns, being immersed in water, holding earthy particles, merely in a state of diffusion, would gradually have every cavity filled with the earth which would be hence deposited; and would also become surrounded with an earthy mass, which, having gradually acquired a pulpy state, would, as evaporation proceeded, obtain, with that which had filled all the cavities of the column, a stony hardness: thus we should have the calcareous animal remains completely filled with, and im-

bedded in stone. The next stage in this assumed process would be the filtration through this stony mass of some menstruum, probably water slightly impregnated with sulphuric acid, yielded by the decomposition of superincumbent pyrites, carrying with it a portion of iron. The effect of the filtration of this fluid through the mass may be easily conceived:—the acid, combining with the lime, would part with the iron, which would be left united with the silicious and argillaceous particles, whilst the lime would be gradually removed. Thus, by the perpetual accession of this very dilute acid metallic solution, the whole of the calcareous matter, as well of the involving matrix, as of the animal remains, would be carried away: and iron, with perhaps a minute portion of silex, deposited in the smaller interstices of the investing stone, and of that which fills the cavities of the entrochal column. By this removal of the calcareous earth, the space which it possessed would, of course, be left empty, and a solid substance would remain, exactly answering to the cavities which the vertebral column originally possessed.

The doubt expressed by Mr. Walch with respect to the presence of silex in the screw-stone, led me to make an examination of such specimens as I possessed.

All the detached specimens which I could obtain, being thirteen in number, were placed in a glass vessel, and covered with diluted nitric acid, when a very considerable effervescence took place, which was soon found to proceed from one specimen. This specimen being removed, it was directly ascertained that the acid exerted no action on the remainder; and that they, like their containing mass, were chiefly formed of silex and alumine, whilst this specimen alone was formed entirely of a very pure calcareous spar.

I will now endeavour to explain the formation of this fossil, aware of the difficulty of the task, as was observed, when speaking of some of the fossil substances from St. Peters's Mountain. This fossil body is entirely composed of a carbonate of lime in a spathose state, and

has taken its form by exactly filling the cavities of the original organized fossil, which also owed its solidity to the same earthy substance, a carbonate of lime, disposed on, and held together by, a very small portion of gelatin. The difficulty of the explanation consists in the ascertaining of what agent could have so completely removed the mould, without having manifested the least influence on the cast, whilst the component parts of both so nearly agreed.

The consideration of the actual difference in the constitution of the cast and of the mould leads, in my opinion, to the desired explanation, and shews that the only agent employed in the removal of the mould was water. Let us suppose a part of the vertebral column of the encrinus to be so situated as to be immersed in, or constantly exposed to, the instillation of a fully impregnated solution of carbonate of lime. From this circumstance, after a certain period, the cavity of the vertebral column may be expected to become accurately filled with a crystalline calcareous spar; whilst the original animal matter in which it is formed may be considered either as impregnated or not with the same substance. After another lapse of time, this body thus filled, it is to be supposed, may be subjected to the action of water. To determine what would here take place, it seems to be only necessary to consider that calcareous spar exposed to the action of water suffers, through a long period, little or no change or diminution; whilst, on the other hand, animal substances, such as shells, the crustaceous parts of animals and other bodies formed by the intermixture of animal membrane, or gelatine, with carbonate of lime, suffer a very rapid decomposition by the agency of water alone, as is the case with dead shells, &c. on the sea or river shores. In these instances it may be ascertained that the animal membrane, suffering resolution, particle after particle, and layer after layer; the carbonate of lime, deprived of its cement and support, gradually separates, and moulders away.

Thus also it is likely to happen with shells or trochitæ, enveloped

and filled by the drusy crystallization of tufa. The animal part suffers decomposition, in the manner just described, by the constant action of simple water, whilst the crystalline calcareous matter, suffering little or no change, retains perfectly the forms which it had derived from the animal remains which have passed away.

In this manner, I presume, the calcareous casts of shells, &c. have been preserved in the Mountain of St. Peter; and thus also I suppose the parts of the vertebral column have been removed in the specimen which gave rise to these remarks, whilst the perfect form of the cavity of the column has been preserved. Calcareous casts of these bodies are, however, I believe, very scarce, when compared with those which are formed in Chert.

LETTER XVII.

LILY ENCRINITE......TRUNK.....PELVIS.....SUPERIOR EXTREMITIES...... NUMBER OF BONES IN THE SUPERIOR PART OF THE ANIMAL.... INFERIOR EXTREMITY.

From the view which has been hitherto taken of the component parts of the vertebral columns of fossil encrini, no doubt can exist of their being divisible into several species: to discover the respective characters of these species is now to be attempted.

From this same general view of the mineralized remains of these animals, there appears to be sufficient reason for adopting the following definition, as containing the generic characters of the fossil encrinus:

Encrinite, *the lapidified skeleton of a zoophyte; in which pentago-*

nal, cylindrical, or oval vertebræ, with radiated or stelliform articular surfaces, compose a trunk, supporting a pelvis, from which proceed five arms, terminating in fingers and numerous tentacula.

The first species which we shall examine, is that which, from the lily-like form yielded by its closed arms, has been hitherto distinguished as the Encrinus, *Lilium lapideum*, or Stone Lily.

The Lily Encrinite *is distinguished by each of its arms, dividing into a hand, formed of two fingers, from the inside of which proceed articulated tentacula: the whole folding up in the form of a closed lily.*

The vertebræ, forming the trunk of this species, appear, from the examination of several specimens, in which the vertebræ and pelvis of the animal are united, to be the trochitæ figured Plate XIII. Fig. 1, 2, 8, 19, 43, 44, as are shewn in the outline sketch, supposed to be continued from the specimen Plate XIV. Fig. 1.

As these vertebræ approach to the body of the encrinus, a curious change is observable: the crenated surface gradually quits the centre, and a slight stelliform figure assumes its place. Thus the vertebra attached to the body of the encrinus obtains a stelliform surface, fitted to articulate with the stelliform surface which always exists in the centre of the pentagonal base of the pelvis. An idea of the manner in which this change takes place may be obtained by inspection of the trochites, Plate XIII. Fig. 19.

By the vertebræ, three in number, which are yet adhering to the pentagonal base of a very perfect encrinite, I am enabled to perceive that the third vertebræ has a slight approach to the pentagonal form, the effect of five slight indentations on its sides. Its edge is slightly crenated, and it bears slight traces of five radii on its surface. The second vertebra, with which this articulates, is larger, and has also a little of the pentagonal form. Its sides are rather tumid, and its border, which is broad, receives within its inner edge the third vertebra on the one side, and the first on the other side, which is similar in form to the third, and doubtlessly bears a star-like im-

pression on the surface which joins the pentagonal base of the encrinite.

From the peculiar nature of the articulation of the vertebræ of the whole column, the crenated edges being exactly fitted to each other, almost in the manner of a dove-tail joint, it is obvious that no rotatory motion could have been performed. It is also evident, that as the motion admitted is that which accompanies the sinking in of the teeth of the articulation into the notches of one side, and the raising them out of the other, as may be seen in the specimen Plate XIII. Fig. 8, it can only be in a lateral direction; but from the circular arrangement of the crenated surface of articulation, it is plain that the animal would possess the power of bending laterally, with equal facility, in any direction, and would thereby enjoy all the advantages of a rotatory power, without the insecurity with which that might have been attended. It is, indeed, true, that as the motion must be regulated by the depth of the crenated edge, and the thickness of the intervening ligament, the quantity of motion depending on each joint, must have been very small; but when it is considered that all the neighbouring joints, and, perhaps, those of almost the whole column, would partake of this motion, it will be evident that, in so long a trunk as this animal may be supposed to have possessed, the power of flexion must have been very considerable.

But in almost every other animal, a greater degree of mobility is given to the vertebral column, as it approaches to the head, or to that part of the animal which is intended to seize and receive its prey; so in this animal a corresponding modification of the articulating surfaces of the vertebræ nearest to the body of the animal, will be found to exist.

In every specimen of the vertebral column of the lily encrinite which I have seen attached to the superior part of the animal, that part of the column next to the pelvis has been thus composed of

vertebræ, differing nearly alternately from each other, both in size and form: larger orbicular vertebræ having smaller cylindrical ones placed between them, as at Plate XIII. Fig. 43 and 44, and at Plate XIV. Fig. 1, where a sketch in outline is given of the conformation of the vertebral column from another specimen.

By this most curious and well adapted species of articulation, the external edge of the smaller vertebræ, articulating with the inner edge of those which include it, the mobility is very considerably increased; since, instead of being limited to the depth of the crenated edge, it is only limited by the collars of the largest vertebræ coming into contact, whilst moving on the external surfaces of the smaller vertebræ which they encompass, as is seen in the specimen Plate XIII. Fig. 8, and has already been observed, whilst describing the trochitæ Fig. 23 and 25. By this admirable contrivance, it seems, that the animal possessed the power of moving its superior parts with all the facility and freedom which its instinctive pursuits might require.

Of the length of the vertebral column but little can be said decidedly, since no instance has yet been met with, in which both the natural terminations have appeared on the same specimen of the trunk, without which it is obvious that no positive judgment respecting this circumstance can be formed. Reasoning, however, from the vast numbers of the vertebræ, and from the very small number of the extremities of this animal which have been found, there appear to be sufficient grounds for imagining that the trunk must have been of considerable length indeed. In one of my specimens, that from which the sketch in outline, Plate XIV. was taken, the vertebral column, still united to the body of the animal, is nearly eleven inches in length.

I shall now proceed to the examination of that part of the skeleton of this animal which formed its body and superior extremities, and which has been hitherto called the lily, the crown, the head, or the body part, Plate XIV. Fig. 3. I shall first examine the basin *(pelvis)*, in

which, in all probability, the parts subservient to the reception and digestion of food were placed.*

This basin, Fig. 3, *a*, *b*, *c*, *d*, is composed of twenty pieces, in four different series. The first of these series consists of *five* cuneiform pieces, *(ossa innominata,)* so adapted to each other, as, when united, (which, in the living animal, they doubtlessly were, by an appropriate ligament,) to form a stelliform floweret, fitted by its risings and depressions to articulate with the first vertebræ of the trunk. One of these is separately depicted, Fig. 3, (a) and the five are shewn in their natural situation in the centre of the inferior part of the basin, where their several risings and depressions are seen to compose a floriform figure, which has the appearance of consisting of five petals.

These are encompassed by five other pieces, *(b,)* which, from their exterior surface being of a trapezoidal figure, are named by Rosinus *Articuli trapezoides;* but these I shall consider as RIBS. Their outer surfaces are smooth and slightly convex, but their internal surfaces, (b) are rendered rough and unequal, by several risings and depressions, which produce such surfaces as are fitted to unite with the corresponding surfaces of the next series. By the union of these two series of bones is formed the *pentagonal base (Basis pentagona*, of Rosinus). of the pelvis, as is represented Plate XIV. Fig. 2.

Upon these are placed five other bodies, of an irregular form, which I term CLAVICLES *(c)*. The outer edges of these are flat and smooth.

* Since it may appear improper, in the following description, to have designated the parts of this animal by terms which belong to the parts of the more perfect animals, it is necessary to observe that, in the less perfect animals, no parts are discoverable, by which those of the encrinus can be so well illustrated.

Thus a *basin,* or *pelvis,* is here formed for the reception of the viscera of the animal, by the *ossa innominata* and the *ribs.* From the external part of this basin proceed the *arms* of the animal, each of which, as in the more perfect animals, articulates on another bone, which I therefore have termed *scapula,* and which, like the scapulæ of the more perfect animals, is connected by one part with the bones of the arm, and by the other with the ribs; its attachment being rendered still more firm by the medium of a *clavicle.*

and nearly form a segment of a circle: their internal edges, which are also somewhat circular, are finely crenulated. Their inferior surfaces, (c, 1) have a few ridges and depressions, by which they are fitted for articulation with the superior surfaces of the bodies (ribs) described in the last paragraph: but their superior surfaces (2) are tolerably smooth, having only a little rising on each, by which they are fitted for articulation with the inferior surfaces of the next series of bodies.

These, *(d)* in their general form, bear some resemblance to the former bodies, but are considerably thicker on their outer than on their inner edges. Their inferior surfaces (d, 1) are a little hollowed out, by which they are adapted to the superior articulating surfaces of the former bodies (clavicles): but their superior surfaces (2) rise gradually in the centre of their outer margins, so as to render their outer surfaces of a triangular form, and to separate their upper into two obliquely disposed surfaces. These oblique superior surfaces are the parts adapted for articulation with the inferior surfaces of the next series. Rosinus unites these with the preceding pieces, and names them, when thus united, *Radices radiorum.* With these bodies, and which I have therefore termed SCAPULÆ, are articulated the ARMS of the animal *(e;)* one proceeding from each of the oblique surfaces of these bodies, and are therefore ten in number. In the specimens which were seen by Rosinus, these arms were formed by seven pieces; but from the examination of those which I possess, I find a considerable difference in this respect: in one instance there are seven; in another, four; and in others, six of these pieces. The first of these, that which immediately articulates with the scapula, is thicker than the rest, and is of an irregular form, much better to be comprehended from its representation, than from any description. To this is adapted a thinner, but somewhat similarly shaped piece; on which, in succession, are disposed other thinner pieces, with which the arm is completed. At *(f)* is represented the two first ossiculæ of the arm united together.

Immediately after these pieces another arrangement takes place: the pieces gradually diminish, *h*, *i*, *k*, and *l*, and form into two series in the following manner: the first two or three terminate at their inner end in a gradually tapering point, and all the succeeding ones terminate in a point suddenly formed, as if by two oblique sections, at that termination. A triangular space is thus formed between the points of each two of these pieces in each row; and by the mutual reception of the several terminating points in these cavities, a remarkably neat hinge-like articulation is formed. These two ranges of ossiculæ, of which about forty are contained in each range, compose two articulated *fingers*, the number of these fingers being twenty, since two proceed from each of the ten arms.

From the internal part of these fingers a considerable number of articulated tentacula are produced: from each ossiculæ of the fingers, a series of from about twenty to thirty still smaller ossiculæ being given off; the contiguity of these series to each other, making it appear as if an articulated web was attached along the inside of each finger. This curious arrangement of these tentacula is very accurately delineated in the representation of the rare specimen Plate XIV. Fig. 1.

With the hope of acquiring a more accurate knowledge of this part of the skeleton, I have, for the purpose of obtaining a view of their internal structure, destined several of these bodies to destruction, by transverse and longitudinal fractures and sections; and in the latter case, by such polishing as their substance would admit. By this mode of examination, I have been enabled to ascertain that on the internal part of each ossicula of the finger a deep cavity exists, to which the first ossicula of each tentaculum is attached by an appropriate articulation; and that, by the articulation of nearly flat surfaces, the ossiculæ of each tentaculum are also connected together. By these means I have also been able to ascertain, that about twenty

ossiculæ enter into the formation of some of the upper and shorter; and between thirty and forty, in some of the lower and longer tentacula. Rosinus, whose accuracy cannot be spoken of in terms too high, remarks, that in all the ossiculæ of which the pelvis, arms, and fingers are formed, foramina, or sinuses, are observable, fitted for the reception of nerves or vessels. Every examination which I have been able to make confirms these remarks; and by examination with a lens of moderate power, of a longitudinal polished section of the articulated tentacula themselves, I found that all their ossiculæ are nearly tubular, having a cavity, which is nearly cylindrical, passing through their substance. That these cavities served for the transmission of nerves and vessels is highly probable; but it appears to be also very likely that the muscular parts also passed through these cavities; this disposition of the muscles appearing to be such as would fully admit of the performance of those motions, on which the existence of the animal depended.

A longitudinal section also shewed that these tentacula, when contracted, are disposed with great regularity side by side, their smaller ends laying towards the upper part of the closed fingers; and by the transverse section I perceived, that in consequence of grooves running along the inner sides of each tentaculum, they became, whilst closed, exactly nitched into each other, so as to give the appearance, in their transverse section, of the mutual insertion of the teeth of two saws.

Rosinus had remarked that these tentacula commenced where the rays or arms began to divide; but by the polished longitudinal section just referred to, I was enabled to ascertain, that these tentacula exist even at the very commencement of the arms.

A careful examination ascertains the curious fact, that, independent of the number of pieces which may be contained in the vertebral column, and which, from its probable great length, may be very

numerous, the fossil skeleton of the superior part of this animal consists of at least twenty-six thousand pieces. To shew this, the following statement is annexed :

Of the bones forming the pelvis, there are five central cunciform bones *(Ossa innominata)*..	5
...................................five ribs	5
...................................five clavicles	5
...................................five scapulæ...............	5
......................arms, there are six bones in each of the ten arms..................	60
......................hands. Each hand being formed of two *fingers*, and each finger consisting of at least 40 ossiculæ ; these, in 20 fingers, make......	800
......................tentacula, 30 proceeding from each of the 6 bones in each of the ten arms, make....	1,800
................................30 proceeding, on the average, from each of the 800 bones of the fingers, make............	24,000
Total.........	26,680

Respecting the inferior termination of the trunk of this animal our knowledge is so exceedingly limited, as not to have furnished us with sufficient materials to have allowed its mention in the preceding character of this animal.

The considering of zoophytes as belonging to the vegetable kingdom would necessarily lead the earlier oryctologists to suppose that the encrinus had been affixed to rocks or some other solid bodies, by a part analagous to the roots of vegetables. Thus Agricola remarks, " Sæpenumero *lapis informis* reperitur unà cum trochite et entrocho, rotæ in se continens figuram ; quæ in eo quasi quædam RADIX, trochitis jam abruptis, remansit." The industrious Rosinus also noticed certain bodies, which he thought might be considered as the primary branches or rays of some species of *stellæ marinæ*, and which certainly

demand attention, from the great probability of their having formed the inferior termination of the trunk of the lily encrinus. His attention was first drawn to these bodies by the accounts which he received from a quarry-man at Asseburg, who had been employed by him in the search for fossils in those quarries. From him he learnt that there had frequently been found, in those quarries, irregularly formed roundish bodies, of the size of a fist, from which the stems of entrochites stuck out like so many fingers; but which, not being heeded by the quarry-men, were consequently lost. Rosinus did not, however, rest until he had obtained a sufficient number of specimens to enable him to form a tolerable judgment as to the nature of these bodies.

The only specimen which I have been able to obtain of this fossil is that which is represented Plate XIV. Fig. 4. This specimen is formed by two series of trochitæ, or by two entrochi, the one twined round the other, and both closely united by a spathose matter. Various similar masses are figured by Rosinus, Tab. X. 1, 2, 3, 4, 5, 6, 7, 8, who considers them as the roots or beginnings *(exordia)* of the trochitæ, belonging to some unknown crustaceous selenitic body, or rather to some hitherto unknown species of sea-star, which he supposes to be characterized by this spathose suffusion.* Harenberg, who, although apprised of the discoveries of Rosinus, believed the encrinus to be a marine plant, necessarily concluded that this plant was attached by a root, which he supposed to be formed of trochitæ of the smallest order, and gives a representation of three masses, similar to those described by Rosinus, marking them as roots consisting of trochitæ.†

Others had regarded these masses rather as concretions of coralline bodies; but it is justly observed by Mr. Walch, that the crenulated articulations of these bodies, which are peculiar to the encrinites, and which are never to be observed in corals, plainly point out to which class these bodies belong.

* Tentam. de Lithozois, P. 81. † Encrinus seu Lilium Lapideum, P. 7.

Possessing only one specimen, which can fairly be referred to the stones here treated of, my inquiries respecting them are not likely to be so successful as I could wish. In this specimen alone, however, I am convinced that I have discovered marks sufficiently strong to prove that the coat by which these entrochi are united was extended over them during the life of the animal, to produce some effect essential to its œconomy.

One of these entrochi *(a)* passes upwards in a straight line, and is nearly surrounded by a spiral turn of the second *(b)*; both being nearly invested by a superinduced spathose matter, marked by two seams running in the line of contact of the two entrochi.

In the lower and fore part of this specimen the twisted column is less thickly covered by this additional matter, and the straight column is quite free from it, for a small space. It is to the examination, which is thus fortunately admitted, of this small part, that I am indebted for the ability to add one more conjecture, as to the nature and use of this substance by which the two series of trochitæ are united together. Part of the trochitæ of the straight column are thus brought to view; and these are, at first sight, seen to differ in their colour from trochitæ in general: the discolouration being very different from that which is found to proceed from different impregnations of a mineral nature. The colour which is here observable is a livid grey, such as would not demand any long consideration in one accustomed to see diseased bone, to induce him to suspect, from the colour alone, that these parts had been under the influence of disease. Being thus impressed by this appearance, I anxiously sought for evidence which might determine how ill or well this suspicion was founded; and therefore proceeded to make inquiry, whether such concomitant circumstances existed here, as might be expected, if any analogy existed between the effects of the assumed disease of these parts and those which are known to accompany the disease of the bone.

Referring to that series of bones, which seems to approximate the nearest to the entrochi, I mean the vertebræ, to the diseases of which, in the human body, particular attention has been paid, two most prominent facts are observable. The one is, that in every disease of these parts in which the substance of the bone has been so materially affected, as to have been rendered unfit for motion, the articulating surfaces anchylose together, so that the morbidly tender parts are no longer liable to injury by motion. The other fact is, that as these parts, weakened by disease, must, of course, be less capable of supporting the weight naturally imposed on them, an exudation of lymph is thrown out, in which is deposited that portion of earthy matter which is necessary to the constitution of callus. By this process, the consequence of injury and of inflammation of these parts, the requisite degree of support is obtained, although the motion immediately belonging to these parts is lost.

The specimen to which I have called your attention bears indubitable marks of these entrochi having been the subjects of both these processes. The naked eye at once sees, in that part of the straight column which is uncovered, an unnatural state of the trochitæ or vertebræ: their forms are not similar, nor are their lines of articulation regular. By a closer inspection, especially with a magnifying glass, it may also be discovered that the processes forming the crenulated edge have been removed, and that a line only slightly undulated, marks where the articulation existed, and shews plainly such a species of connection between the trochitæ as must have occasioned a complete anchylosis.

Equally positive is the evidence in favour of the substance, in which these entrochitæ are involved, being produced by the powers of restoration possessed by the animal. Its colour, its texture, and, indeed, its general appearance accord so exactly with those of the entrochi themselves, as to render it indubitable that it has proceeded from a similar organization.

Presuming that the discolouration of the parts, their anchylosis, and their superadded powers of support, prove previous disease, and the consequent exertions of the healing powers of nature, I shall next endeavour to discover whether these circumstances will at all contribute to any further knowledge respecting the nature and economy of this curious animal.

Attention to the principles by which these processes are conducted, teaches us, that such an union as has been just remarked, does not take place between the parts of different animals, except between such as either do not possess the powers of locomotion, or are incapable of any considerable motion of the parts of which they are composed, as is the case with shell-fish. But the form and structure, and in particular, the numerous articulations of this animal, shew that, even if the animal itself had been fixed, like other zoophytes, to a base, this part of it was susceptible of considerable play, and that therefore such an union would not be likely to take place between the parts of different animals, even of the same species; and hence we may conclude that the two united columns of vertebræ in this specimen belonged to one animal. But further, since, upon the authority of Rosinus, it appears that several of these columns may be thus united, we may conclude that several of these trunks may proceed from the same base. That it is that part of the vertebral columns nearest to their inferior termination, or to their union with their base, appears to be highly probable, from these united vertebræ being apparently of the largest order, and from the marks of injury, and of most careful reparation, being most reasonably expected to be found near to their termination or point of attachment, where, necessarily, must have been their greatest play, and the greatest probability of their sustaining injury and requiring support. Every circumstance, then, being taken into consideration, there exists, I think, considerable reason for supposing that this fossil was the inferior termination, or organ of attachment of this animal.

LETTER XVIII.

REFLECTIONS ON THE NATURE AND STRUCTURE OF THIS ANIMAL... THE ANIMAL DESCRIBED IN VARIOUS STATES.

When the various contrivances observable in the skeleton of this animal are examined, but particularly when its nature and economy are assumed, from inferences fairly drawn from the peculiarities of its structure, the contemplation of such a display of the Supreme Wisdom cannot but excite a high degree of admiration and reverence. In the trunk we perceive every arrangement made in the articulation of the vertebræ, to yield to the animal the power of seeking its food in every direction; whilst the most careful provision has been also made by the adjustment of numerous corresponding projections and depressions, to secure the vertebræ from dislocation.

In that part of the skeleton which formed the superior extremities of the animal, and which has been here occasionally spoken of as the fingers and tentacula, such a disposition of the parts is at once discoverable, as is most excellently adapted for the promptly opening and closing of these parts, as the economy of the animal might demand. It is evident, from the structure of these parts, that the animal possessed the power of almost, if not entirely, displaying them in a horizontal position.

In this position, it may be supposed, the animal would dispose these parts whilst seeking his prey; but to ascertain his mode of seizing it

requires a little further examination. The pieces forming the fingers are evidently capable of two kinds of motion; the one being that of flexion and extension, and the other a degree of lateral motion, by which the two webs of tentacula of the two fingers of each hand, would be either made to recede from each other and assume a horizontal position, or to approximate to each other, and acquire at the same time a perpendicular direction.

Supposing these parts extended in an open and horizontal position, and the prey within reach, then the animal, by raising the tentacula in a perpendicular position, would bring them together, and secure the prey betwixt them; and if by bending the fingers together at the same time he closed these, the prey would then have been directed towards the mouth of the animal, which, with the stomach, &c. may be expected to have possessed the central part of the pelvis formed by the ossa innominata, ribs, &c.

Viewing that part which has been suspected to be the inferior extremity of the animal, we see every reason for supposing that it possessed to a great extent that property, which might *a priori* have been expected in that part which might be considered as the organ of attachment, and by which the animal was to be firmly secured to his destined dwelling-place. In that part we find a propensity to pour out a coagulable lymph, or ossific matter, so abundantly as must have been well fitted, not only to fix him firmly to any particular spot; but to supply the means of repairing any injury which this part might sustain; and, perhaps, of furnishing an additional mode of increasing the species, by enabling any detached columns to attach themselves to a new spot, where they might live independent of the parent stock.

Hence it not only appears that this fossil was originally the osseous or crustaceous covering, fitted for the reception of the softer parts of an animal; but it is also apparent that here excited the most curious arrangement of parts, in every respect fitted for securing the means

of nourishment and existence to an animal which was intended to dwell, like a plant, on one particular spot.

The fossil Plate XIV. Fig. 1, formerly in the collection of the late Mr. Jacob Forster is beautifully illustrative of the internal structure of this animal. The lower part of the closed encrinus, with a part of its vertebral column attached, is here imbedded in a matrix, formed of detached vertebræ of this animal, mingled with the mineralized remains of other marine animals. In the upper part of this specimen, the accidental removal of the terminating bones of the fingers has afforded a clear and distinct view of the tentacula in the natural situation which they hold, whilst the superior extremities of the animal are in a state of contraction. I am indebted to the correct pencil of Mrs. Sheffield, of the Polygon, Somers' Town, for the exact delineation of this specimen, as well as for the elegant drawing of the fossil which appears in the frontispiece.

From this animal having been generally found in a contracted state, it has been supposed that this state resulted from its thus contracting itself together during its dying struggles. It is, indeed, most probable that, on the sensation of the least injury, the animal would immediately firmly contract itself, as appears to have been the case with the animal in the specimen here figured. But in another specimen, instead of this close firm contraction, the arms and fingers appear to have merely collapsed together; the terminations of the fingers laying out so extended as to give much more the appearance of privation of power, than of that of energetic contraction. In another specimen, appearances very different from these last mentioned offer themselves to our observation. The body, arms, &c. are not only in the finest preservation possible, but have, at the same time, that sharpness and fulness which cannot fail to give an idea of the high degree of health and power which the animal possessed at the moment previous to its death. In this specimen, as if prevented by some inter-

vening retained substance, the fingers are not completely closed; but their points, as if to secure the seized prey, or overcome the opposing resistance, appear to have been forcibly contracted downwards and inwards.

The knowledge of the several parts of the world in which this species of encrinus has existed in a mineralized state, is only to be attained by the discovery of the skeleton of the body part, the vertebræ themselves not possessing characters always sufficiently distinguishing to determine whether they belonged to this species or not. There is no part of the world in which this species has been hitherto known decidedly to exist, but in some of the states of Germany. Lachmund first discovered a part of the encrinus, with its appropriate vertebræ, in the neighbourhood of Hildesheim, in Lower Saxony.* Rosinus also discovered the specimens, the nature of which he so successfully investigated on the summits of the mountains in the neighbourhood of Obernscheden and Azzenhusen, not far from the town of Gemenden, in Lower Saxony.† Ritter mentions a mountain named Rakenberg, near Goslar,‡ in the territory of Brunswick, in Lower Saxony, where this fossil is found. The six-rayed encrinus, described by Bruckmann, is also enumerated by him among the subterranean treasures of this part of Saxony.§ Beuth describes two encrinites of this species, which were dug from a mountain at Scwerven, in Juliers, in Westphalia.||

The southern part of Lower Saxony, and the adjoining part of Westphalia, appear to be almost the only parts where this fossil has

* Oryctographiæ Hildesheimensis Præfamin, P. 3.

† Di Lithozois ac Lythophytis, P. 2.

‡ Oryctographiæ Goslariensis, P. 20.

§ Thesauri Subterranei Ducatus Brunsvigii, P. 65.

|| Juliæ et Montium Subterranea, &c. Francisco Beuth, P. 84.

been obtained; and here its remains are so plentiful, that, in several parts, the buildings are formed of a stone almost entirely composed of its vertebræ. But specimens of the body part of the skeleton, especially those with any part of the vertebral column attached, are now exceedingly rare, which is not to be wondered at, when it is considered with what avidity they have been sought; and that the finer specimens, those which have had one side free from the matrix, must have almost, of necessity, laid near to the surface of the rock, exposed to the search of collectors. The matrix in which these remains are found appear constantly to be limestone, and the organic remains themselves are always spathose; but, perhaps, from the deficient proportion of the crystalline matter, interposed between the animal remains, the stone does not, on polishing, yield an appearance sufficiently beautiful to occasion its being employed for ornamental purposes.

LETTER XIX.

CAP ENCRINITE OF DERBYSHIRE, AND, PERHAPS, OF YORKSHIRE..... SUPERIOR TERMINATION.....SUPPOSED INFERIOR TERMINATION..... TURBAN ENCRINITE OF SHROPSHIRE.....PELVIS DESCRIBED..... INFERIOR EXTREMITY.....PECULIARITY OF ITS TRUNK.....SAME COLUMN FROM GOTHLAND.

THE species of encrinus to which I shall now lead your attention, is one which, although its remains are most extraordinarily abundant in our own country, its history is, perhaps, least of all known to us. Indeed we at present know little more of it than that the petrified remains of its vertebral column, either in detached pieces, or agglutinated together in masses of limestone or marble, have long been found in quarries of an immense extent in some of the northern counties of this island.

Mr. Da Costa remarks that the whole metallic tract of the county of Derby is, as it were, one continued quarry of this marble; most of the strata of limestone are of this kind, it being the common stone which is burnt for lime. The upper parts of these strata, he observes, are always filled with amazing quantities of these bodies and other marine remains, which seem to have been lodged there by subsidence; and to have formed a crust over the limestone. This crust is generally of a very great thickness, and when they have passed it, they find the limestone to contain fewer marine remains: and at greater depths it even becomes quite pure and free

from them. The marble does not always display the forms of these remains with equal fineness and perfection: Rickledale, Monyash, and Breks, he mentions as affording the most beautiful.* At present, none, perhaps, exceeds that which is obtained in the neighbourhood of Ashford in the Waters. Da Costa remarked, fifty years since, of the Derbyshire marble, that it is degraded by the common name of limestone; and the country people, ignorant of its value, only burn it for lime, although for hardness, beauty, and susceptibility of polish, it may vie with the most esteemed foreign marbles.

Mr. Mawes, in his Instructive Mineralogy of Derbyshire, observes that the limestone, the whole of which stratum is composed of marine exuviæ, is of various thickness, from four fathoms to more than two hundred; beneath which, separated from the former by a stratum of toadstone, it is ascertained that there is another stratum of limestone, beyond which no mine in Derbyshire has penetrated.†

Anxious to obtain all the information respecting this animal which I might be able, I obtained from Ashford a slab of marble, which had very much excited the attention of Mr. Whitehurst, and of several philosophical characters who had visited that part of Derbyshire; it being the largest level slab, with the animal remains in relief, that had been there met with. This slab, almost entirely composed of these remains, has one surface, which is completely covered with projecting fragments of the vertebral column of this animal, and is four feet and six inches long, two feet and six inches wide, and from two to three inches in thickness.

On this very considerable quantity of surface, I entertained great expectations that I should be able to discover some traces of the superior and inferior extremities of the animal; but in this I was en-

* Natural History of Fossils, P. 236.

† Mineralogy of Derbyshire, P. 12.

tirely disappointed. In this whole mass, in which is a connected series of vertebræ of nine inches in length, and which may fairly be extended to more than three times that length, by reckoning the displaced pieces which it is evident were once in continuation with it: in this mass, in which not half an inch is free from the vertebræ of this animal, and in which it may be safely inferred, that some of the vertebral columns passed through the whole length of the slab, not the least trace of any regular termination can be discovered. Its examination, however, furnished the following facts:

In this assemblage of vertebræ, which there is every reason to suppose must have belonged to one particular species of this animal only, a very considerable variety of form and of combination may be discovered: some being exactly the same size, forming a column uniformly smooth and even; some being alternately larger and smaller, forming a column with alternate risings and depressions; some becoming gradually larger, and then again contracting in size, and thereby acquiring a bulging form; and others having regular articular depressions in their sides for the reception of lateral processes. Besides these, a great number of varieties are here observable, too many, indeed, to allow of being particularized; and sufficient to shew that it would be rather difficult to detect the species of the animal by the form and appearance of the vertebræ.

The general character of the trochitæ of this species appears, however, to be that they are pierced with a much larger foramen than that which is observable in the trochitæ of other species. The trochitæ, Plate XIII. Fig. 29, and Fig. 42, appear to have belonged to this species: as well as the silicious cast, Plate XIII. Fig. 10, and the casts existing in the mass of screw-stones formed of chert, and represented Plate XV. Fig. 6.

In another slab from the same place I was, however, more successful, it containing that part of the skeleton of the body which has been called, in the stone lily, the pentagonal base. It, however, differs essentially from the corresponding part in that species, as appears

by the annexed figure, Plate XV. Fig. 2, the central pentagonal part projecting in a more rounded form, and with the same sweep with the five surrounding and including pieces; whilst, in the corresponding base of the former species, the central part is considerably sunk.

What was the form of the rest of the pieces constituting the pelvis for the reception of the body of the animal; or what was the shape of the ossiculæ forming the arms, fingers, tentacula, &c.; or in what manner these were given off and divided, are questions which I do not possess the means of solving. Numerous ossiculæ, however, are observable on the surface of the matrix; but their forms are not seen with sufficient distinctness to allow them to be clearly made out.

Whilst this sheet was in the hands of the printer, I was favoured with a letter from ——— Stevens, Esq. of Bakewell, near Chatsworth, informing me that he was in possession of the only head, or superior part of the Derbyshire encrinite, that he had heard of. The sketch which Mr. Stevens sent at once assured me that this encrinite differed essentially in its general form, as well as in the arrangement and division of its limbs, from any encrinite which I had seen. Anxious to fill up the chasm which existed in the natural history of this curious animal, I gladly accepted of this gentleman's very obliging offer of the opportunity of having a drawing made from his specimen, and of presenting to my readers its correct representation, Plate XV. Fig. 9. This fossil presents, at first sight, a sufficient difference in its general outline to authorize the conclusion of its being of a different species from the lily encrinite of Germany.

By a closer examination of this interesting fossil it will be seen that from a pentagonal base, similar to that which has been just described, as the supposed pentagonal base of this encrinite, ten arms proceed, as in the lily encrinite, but which soon assume a very different character from those of that fossil. In the lily encrinite, each of the arms divides at the same distance, and in the same manner;

but in the Derbyshire encrinite, as far as can be judged from this specimen, hardly any two of the arms divide alike. Indeed, so irregular is their division, as to render it very difficult to give an idea of it by words. In some of the arms the division takes place very low, even at the third, and in others not until they have reached the seventh or eighth articulation. Unlike, too, to what takes place in the lily encrinite, the fingers, which are formed by this division, divide and subdivide, and that, apparently, not in any particular order; one of the fingers of the same arm appearing to pass undivided to its termination, whilst its fellow finger suffers a still further division. How many divisions actually take place before their termination is completed cannot be determined by the present specimen, since full a third part of it is concealed by being immersed in its matrix; nor can any thing be said of its tentacula, excepting that analogy will lead us to conclude that they are nearly alike in form and arrangement to those of the lily encrinite.

I had already remarked that the contour of the pentagonal base of this species which I had first noticed, Plate XV. Fig. 2, differed from that of the lily encrinus in being more rounded; and by the specimen of Mr. Stevens, it is seen that this circumstance results from its adaptation to the general form of this species, which is characterized by its rounded and pyriform figure.

With respect to the lower extremity of this species, I do not know that any conjecture has been made, as to the form it assumes: I, however, have some reason for suspecting that the spathose fossil, Plate XIV. Fig. 5, is a polished section of this part. It was originally in the collection of Mr. Strange, but where it was obtained from I have had no opportunity of knowing.

This fossil has been longitudinally divided, so that the section shews a trunk, which seems to have been transversely divided, at small distances, and from which appear to have proceeded cup-formed lamellæ, disposed like those of a tunicated bulb. These have been

about seven in number; and although their continuity appears to have been broken, their number may be pretty correctly ascertained at the other end, where they are seen contracted together, and having their terminations adorned with fimbriæ of a plumose appearance. Although by no means assured of the real nature of this fossil, I have thought it right to place a sketch of it before you, since the observations of others may correct the opinion I entertain respecting it. It may not, however, be amiss to remark that I have seen forms on the polished surface of the Derbyshire marbles, which, I think, bear an exact resemblance to that of the substance which is here figured.

The pear-like shape of this encrinite would seem to direct the best term by which this species might be distinguished; but an encrinite to be hereafter described offers an equal claim to be denominated the pyriform encrinite. Besides which consideration, there is another of some weight. The pelvis of the encrinite now under examination has much of the form of a cap, whilst that of the encrinite which we shall next examine is so much more elegantly formed as rather to resemble a turban. To distinguish these two, it therefore seems well to term the former the CAP ENCRINITE, and the latter the TURBAN ENCRINITE; whilst that, the pelvis of which is pyriform, appears best to deserve the denomination of the PEAR ENCRINITE.

In several parts of Yorkshire and Lancashire marble formed of encrinal remains are found in very considerable quantities; but whether this encrinite is the same with the cap encrinite of Derbyshire, I am incompetent to determine, the Yorkshire encrinite being only known to me by its vertebræ. With the hope of obtaining some information respecting the animal whose remains were thus preserved, and especially for the sake of ascertaining whether it was of the same species with that whose remains are detected in the Derbyshire marble, I requested my worthy and intelligent neighbour, Mr. William Inman, to collect for me some illustrative specimens, as well as to make such observations on the quarries, &c. as he should be able, whilst visiting that

part of the country. By the kindness of this gentleman I was furnished with such specimens as served to shew me that, as in the Derbyshire, so in this marble, the remains of any other part of the animal, except of the vertebral column, are exceedingly rare: indeed I was unable to discover the least trace of either the superior or inferior extremities in any of the specimens which came under my observation. With respect to the situations, in which the marble, with which he favoured me existed, Mr. Inman gave me the following information:

" These specimens were obtained from a place called Garsdale, situated in the north-west part of the West Riding of the county of Yorkshire, on the confines of Westmoreland. It is a deep and narrow dell or dale, about seven miles in length, running due east and west, having no level ground, except a few fields at the foot of two exceedingly high mountains, which form its sides. This level, according to all appearances, consists of the various substances which have been washed by the rain from the top and sides of the adjoining mountains, and now form some of the richest pasture-ground in the kingdom. The specimens were taken from a quarry, lately discovered to be fine rich marble, about half way up the side of Bafell, or Bowfell, (being something like a bow in appearance on one of its sides); one of the mountains forming Garsdale, and one of the highest and grandest in the north of England, being in my opinion, as high, if not higher, than Skiddaw, and much grander in appearance. It is at its foot, I should think, full thirty miles in circumference; and its top (except in very clear weather) is mostly enveloped in the clouds. The highest parts cannot at any time be seen from the valleys which surround it; to see its highest elevation will require nearly two hours of persevering labour, in ascending its rugged side. The prospect from one point of the top of this mountain is very extensive, as the sea may be seen from it on a clear day, over about thirty miles of mountainous country in Westmoreland. Some parts of the top consist

of broken moorish earth, with scarcely any vegetation on it; others are covered with loose sandy stone. There are also at the top, at, I think, about two miles distance from each other, two tarns, or lakes, of many acres extent each, the bottom of one of them, so far as can be seen, is formed of fine light grey sand. There are also, on different parts of this mountain, many slate quarries and coal-mines, likewise vast tracts of peat earth.

"But to return to the marble quarry: it lies, as was observed before, about the middle of the ascent, up the side of Bowfell, fronting, or forming one side of Garsdale. The ground there, and in its vicinity, is moderately level, compared with that which lies above and below, and is rather of a swampy nature, abounding with springs, where the earth has been moved to uncover the beds of stone, which lay near the surface of the ground; the blocks of which are of great magnitude. At a small distance from this spot, east and west, are two projecting dry limestone hills, parts of which appear to be formed of similar marble, and it is, perhaps worthy of observation, that on the mountain on the opposite side of the valley, are seen two other hills of a similar nature, (as near as the eye can form a judgment,) on the same level. This marble is in great request in the north part of the island; it is carried to Kendal, about eighteen miles from the quarry, where it is manufactured into chimney-pieces, slabs for sideboards and monuments. In the course of my journey I saw several chimney-pieces and monuments which had been made of it. There is a great demand for it at Manchester, Liverpool, &c. It is worthy of observation that, at the head of Garsdale, the water separates and runs east and west, and joins rivers which fall into the sea at opposite sides of the island, viz. That which goes east forms a part of the river Swale, which passes by Richmond and Thirsk and falls into the Ouse, and then into the Humber: that which runs west down Garsdale, is called the Clouff, and joins the Lune near Sedbergh, and falls into the Irish Sea below Lancaster."

Plate XV. Fig. 3, is the representation of a specimen of the Yorkshire entrochal marble, in which the organic remains are very beautifully disposed in relief on its surface. As I have already remarked, I am unable to discover any essential difference between the entrochi existing in the Yorkshire and in the Derbyshire marble. Those in the Yorkshire marble seem, however, to be generally smaller, and of a neater conformation than those in the marble of Derbyshire; but whether this proceeds from real difference of species cannot, perhaps, be determined from such specimens only as I have had the opportunity of seeing. The colour, in different specimens of the Derbyshire and Yorkshire marbles, varies much from a light to a dark brown. This specimen is of the latter hue.

Plate XV. Fig. 2, represents a polished specimen of this marble, formed of the mineralized remains of separated columns of trochital vertebræ. By attention to the different sections of these columns, a tolerably correct knowledge of their construction will be obtained; remembering that the lighter parts are the remains of the original animal substance, and that the darker is the interposed crystalline matter.

From the observations which I have been able to make on the remains of the encrinus in the limestone, or rather marble, of Wenlock Edge, in Shropshire, I am fully satisfied that it is a species different from both the lily encrinite and the cap encrinite of Derbyshire. My reasons for forming this conclusion I shall now offer to your consideration.

The calcareous masses of the remains of encrini which are obtained from Wenlock, possess certain characters which immediately distinguish them from such masses of entrochal marble as are obtained from any other part. The organic remains themselves are formed of calcareous matter, which being apparently very free from any ferruginous impregnation, is nearly white; and hence the organic remains are, some of them, beautifully white and opaque; whilst others, with

an equal portion of whiteness, possess even some degree of transparency. Besides the difference of appearance proceeding from the nature of the calcareous impregnation, a considerable difference arises from the combination of other animal remains with those of the encrinus, a circumstance seldom occurring in the Derbyshire or Yorkshire masses. These other animal remains, which nearly equal in quantity the remains of the encrinus, are of the coral kind: chiefly of small, elegant, ramose milleporæ, mingled with fragments of the Tubipora Catenulata, and with other marine remains, the natures of which are not to be correctly ascertained. Much of this difference of appearance also depends on the different characters of the remains of the encrini themselves, as will appear from the following remarks.

The fragments of the vertebral column are almost all composed of vertebræ which are exceedingly thin, and disposed in a series, in which very thin vertebræ alternate with those which are less so, the latter projecting a little beyond the former; so that the column is transversely ridged in a regular and elegant form, similar to what is represented at Plate XV. Fig. 7.

The vertebral columns in the specimens I possess are marked by characters which seem almost certainly to point out a specific difference between the encrinite to which they belong, and those which have been already examined. Extreme thinness of the vertebral trochites is a character which, alone, seems to be sufficient to separate the animal of this species from those already noticed; this property being observable in every part of the vertebral column which I have seen. From a careful examination of the two masses of these remains which I possess, I was much pleased to discover that the one was chiefly composed of the fragments of ossiculæ which had belonged to the superior, whilst the other was almost entirely made up of the remains of the inferior part of the animal. To the investigation of the characters which these possess I now claim your attention.

Plate XV. Fig. 7, is part of the mass belonging to the superior part of the animal, which is proved by the body part, or pelvis, being imbedded in it, and being surrounded by a confused mass of minute ossiculæ, which had formed the arms, fingers, &c. of the animal. As in the skeleton of the body part of the other encrinites, so we find in the skeleton in this specimen, that the first of the vertebræ is surrounded by five bony plates, which, in the account given of the preceding species, were considered as ribs: but the similarity of structure ceases here, the remaining parts of the skeleton being essentially different.

Each of the ribs, viewed externally, the only view which I have hitherto obtained of them, presents a roundish flattened surface, terminated by six articulating edges. The first of these, the inferior concave edge, is that which surrounds the external surface of the first vertebra. This edge is on a line which forms the fifth part of the internal and smaller circle of the pelvis. Opposite to this, is the exterior convex edge, on which the compound clavicle of this species articulates; this edge forms also the fifth part of a circle, but is necessarily larger than the former, as it includes the more external part of the pelvis.

The ends of each rib terminate in two obliquely disposed edges, forming the articulation by which the ribs themselves are connected together. By a truncation, as it were, of the angle resulting from the edge just described, and of the superior edge, an oblique edge is formed, which, with that on the corresponding part of the adjoining rib, leaves a triangular cavity immediately over the commissure of the ends of the ribs. In this triangular cavity is placed the inferior termination of an oblong body, which appears to have had an analogous office with that which was considered as the scapula in the lily encrinite; since to its superior part, the arms, fingers, &c. of the animal appear to have been attached.

Between each of these five scapulæ, and on the superior edges of the

ribs, are placed the clavicles, each of which is composed of five pieces: a central orbicular piece placed on the centre of the superior edge of the rib, with an oblong piece, attached to it on each side, and two triangular pieces filling up the cavities left between the tops of the last-mentioned pieces, of the orbicular pieces, and of the scapulæ.

It was endeavoured to be shewn, whilst treating of the lily encrinite, that a greater extent of motion was given by the alternation of wider and narrower vertebræ, and by the edges of the former overlapping those of the latter; and it was seen that this arrangement constantly took place, in that part of the column which was nearest to the body of the animal. A similar conformation and arrangement of the vertebræ exist in by far the greater part of the fragments of the vertebral column which are found in this mass, and therefore may be concluded to be the fragments of that part of the column, which was nearest to the skeleton of the body of the animal.

I was much pleased by obtaining, at the sale of Mr. Strange's museum, a calcareous mass from Wenlock, which is rendered exceedingly interesting, by its containing that which I conceived myself to be fully warranted in considering as the inferior termination of this species of encrinite. Like the former, this mass is chiefly made up of the fragments of the vertebral column, intermixed with pieces of a small ramose millepore, and a few other marine remains; but, unlike those of the former mass, the fragments of the columns, with the exception of two or three only, are composed of vertebræ of a similar thickness, from which it may be concluded that they did not belong to that end to which the skeleton of the body part of the animal was attached. The vertebræ are here all exceedingly thin, with a circular central foramen, and a very finely crenated surface. In some of the vertebræ, which form the column most distinguishable for its size, an obvious peculiarity of character is observable: some in one part and some in another lose their circular form, by lateral protrusions, in which a central foramen is observable. By these projections from the sides of the vertebræ, the column acquires a rough

and unequal surface; being beset with knobs, which are the commencement of so many radicles.

The vertebræ terminate in the body above alluded to as the inferior termination of this encrinite. It has been accidentally broken, but in the most desirable manner; since the fracture having been made longitudinally through its middle, its central structure is fully displayed. We thus also perceive eight very thin and very finely crenated vertebræ, over which a thin coat appears to be extended, which is likewise extended over various tubular radicles, which ramify and diverge in every direction around the vertebral trunk. In one part, one of these radicles is seen so fractured as to shew its crenulated articulations, the crenulæ, however, being so exceedingly shallow that they could have yielded little or no capacity for motion. In the other part of this radicle, the substance is considerably contorted; several projections, with a foramen in the centre of each, are seen on its surface, and the articulations are so obliterated as plainly to shew that no motion could here have taken place.

The nature and uses of the parts just described are clearly ascertained by the extraordinary and unique specimen Plate XV. Fig. 5, which, from the purity and whiteness of the calcareous matter of the organic part, and from the colour and other sensible qualities of the matrix in which it has been imbedded, there is no doubt was also obtained from Wenlock Edge.

Extreme thinness of the vertebræ, it has been already observed, appears to be one of the characteristics of this species of encrinite; and, in this specimen, this character is very observable; since although the trunk, from which the roots proceed, is only about an inch in length, upwards of thirty vertebræ enter into its formation. These vertebræ exactly resemble those of the column, in the mass already noticed, in their articulations being so little crenulated, that they have been evidently capable of little or no motion: and, in their being, in the same manner, beset with numerous projections; each

of which is pierced by a foramen. These foramina, as may be seen on the flat surface of the uppermost vertebræ of this specimen, reach to, and unite with, the central circular foramen. Each of the vertebræ being thus beset with these projections, the trunk is thereby rendered very rugged; and still more so, as the vertebræ approach towards the ramose termination, where the projecting processes gradually acquire an increase of length. On acquiring about a quarter of an inch in length, these processes separate into ramifications, and continue thus to ramify, at the distance of a quarter, or of half an inch, until they form a brush-like mass, as is above represented.

It was observed, when speaking of the lily encrinite, that the crenulated articulation was obliterated, or nearly so, in those parts which appeared to have performed the office of pedicles to the animal. A similar circumstance is observable here; for among the ramifications above described, there are several in which traces of the almost obliterated crenulated articulations may be perceived: and where the internal part of these bodies is exposed, as may be seen in the figure, they are found to be hollow, and manifesting similar traces of the original crenulated articulations.

When the similarity of the vertebræ in this specimen, and in that mass in which the skeleton of the body part of the animal is imbedded is considered, little doubt can exist as to their both being parts of the same species: and when the form and construction of the ramose parts of this specimen, so well adapted for performing the office of pedicles, are contemplated, as little hesitation can occur in admitting that these parts constituted the inferior termination, the organ of attachment, of this species of encrinus.

Having, I trust, established the existence of this peculiar species, I shall call your attention to the peculiarities observable in its vertebral trunk.

The specimen Plate XV. Fig. 4, which is formed of a spathose substance, with a reddish tinge, is particularly interesting from its differ-

ing so very materially from every other species of trochital vertebræ. Like other entrochi, it is of a cylindrical form, but is somewhat flattened, and, most probably, by compression. The vertebræ of which it is composed are extremely thin in proportion to their width, being scarcely an eighth of an inch in thickness, although upwards of an inch in their medium diameter; every vertebra being most thickly, and at the same time irregularly, beset with very small holes. In consequence of the exceedingly fine striæ on their surfaces, the lines of articulation are so very fine, as hardly to be visible, except the eye receives the aid of a magnifier; when it is discovered that the notches in the lines of articulation are so small, as to have the appearance of being very finely serrated. The direction, too, of the articulation, is also very uncommon, being irregularly undulating; this irregularity evidently proceeding, not from any modification of their form, from any circumstance attendant on the change from the animal to the mineral kingdom; but certainly from a concurrence of arrangement with the minute openings which have been just particularized. Hence it is to be seen that the line which marks the articulating surface takes the middle of the intervening spaces between these openings, so as sometimes to include one, and sometimes two rows of the openings, falling in with, and exactly adapting itself to, their irregular disposition.

This specimen also formed a part of Mr. Strange's museum; but of where it was obtained from, I have no information; its close agreement, however, with some specimens, of which I shall presently speak, seems to determine, almost decidedly, on its having been obtained from the Isle of Gothland.

The fossil Plate XV. Fig. 8, accords so nearly with the preceding, as to render many of the observations which I shall now make applicable to both. Like the former, this specimen is composed of very thin trochitæ, which are connected by the articulation of their very minutely serrated edges. In this the small openings are disposed with much more regularity than in the former specimen, they being

placed at nearly equal distances, and almost in straight lines: the lines of articulation preserving the same direction. This specimen, I have reason to believe, is from Wenlock Edge, to which place, or rather to its fossil productions, I shall soon have to recur. In another specimen, not marked with sufficient distinctness to be employed as a subject for delineation, a middle state, as it were, is to be observed. The minute openings, as well as the lines of articulation, are disposed with much less regularity than in the specimen just described, but with considerably more than in the preceding.

In Knorr's elegant work, a fossil is depicted which is evidently of the same species with those which are here figured; the regularity with which its lines of articulation and its small openings are disposed rendering it most like that which is represented Fig. 8. From the remarks of Mr. Walch on this fossil, we learn that it was obtained from the Isle of Gothland; and that its specimens are sometimes, as is the case with Fig. 6, pervaded with a tinge of red. They differ much, he observes, in thickness as well as in length; some being not more than half an inch, whilst others are two inches in thickness; they vary also in length from one to five or six inches. It is, however, well deserving of remark that, according to Mons. Klein's account, the limeburners of Gothland often find these entrochi of the length of an ell. Their central opening, Mr. Walch observes, varies as in the other entrochi, being sometimes circular, and sometimes, though very rarely, stellated. It is only with the assistance of a glass, he observes, that the lines of connection between the trochites, as well as the numerous little openings between these lines, are to be plainly seen. Of these openings, he says, it is observable that they pass through the substance of the trochites, and open into the central canal; and in general, he says, they do not bear any marks of having given off branches; although, he observes, it is certain that some, at least, do ramify; since, in a specimen which he possesses, there is a ramification, which is given off from the larger trunk, possessing similar

openings and similar articulations with those which are seen in the trunk itself. On the specimen described by Mr. Walch, he remarks that there also exist several mammillary projections, resembling small branches, and which, being placed over some of the openings which pass from the centre to the circumference, have these openings or holes continued quite through them. If, he observes, we have a right to suppose that similar little branches were placed over all these little openings, these branches must have been exceedingly small, and so prodigiously numerous, as to give it the appearance of a brush.

The following differences, it must be admitted, serve to place these entrochi, and of course the encrinus to which they belong, under a distinct species. The width of the column appears to much exceed the width of entrochi in general; the lines of articulation are much finer than in other entrochi, and are not so regularly disposed: hence a degree of irregularity in the thickness, and in the figure of the trochites themselves, which is unknown in other trochitæ. From this discordance many had been disposed to consider these bodies rather as ramified corals than as entrochi; but Mr. Walch observes that they agree with these bodies in every essential circumstance, and therefore should be considered as the parts of the trunk of an encrinus, which, judging by the size of the stem, must have been of a very considerable size. If the stems of an ell in length, found by the limeburners of the Isle of Gothland, were but of the ordinary thickness, then, as Mr. Walch observes, the stems of such a thickness, or that which is possessed by the specimen, represented Fig. 6, should be, in proportion, of three ells or more in length. How much, he remarks, does there here remain to be discovered!

The exact accordance of the Gothland fossils with the stem of the Shropshire (the turban) encrinite, in the thinness of the trochitæ, the fineness of their radiating lines, the numerous lateral openings, and the protruding processes, shews, indubitably, that these fossils have all belonged to the same species of encrinite.

LETTER XX.

PEAR ENCRINITE OF BRADFORD.....SUPERIOR EXTREMITY.....INFERIOR EXTREMITY.....FOUND ALSO AT PFEFFINGEN.

Although aware of the very imperfect state of the several fossils which I shall place before you, in illustration of the next species of encrinite, I am yet induced to hope that I shall be able not only to satisfy you of its having existed as a distinct species, but to supply you with the means of forming a tolerably correct notion, respecting the form and structure of the skeleton, and of its superior as well as of its inferior extremity.

The first, and I believe, indeed, the only notice which has been hitherto taken of the remains of this animal, is to be found in the "*Descriptions and Figures of Petrifactions, found in the Quarries, Gravel-pits, &c. near Bath. Collected and drawn by John Walcott, Esq.*" Page 46, Fig. 61, seven of the connected vertebræ, and one of these separated, are figured by Mr. Walcott, whose only account of the former is "a conoid body of seven joints;" and of the latter, "one of the joints, except a small breadth from the edge, which is flat, both sides are concave, which makes the edge of the hole, which is in the centre, very thin. Found in the pits from whence they dig stone to make the new road leading from Kingsdown to Bradford, &c."

Not being able to obtain any farther information respecting this fossil, than the little which was yielded by Mr. Walcott's account, I,

for three or four years, procured all the specimens which I thought would throw any light upon its history. My endeavours would, however, I suspect, have been attended with very little success, if my very kind friend, Mr. Townsend, had not availed himself of his vicinity to Bradford, and favoured me with such specimens as he considered would be most likely to facilitate my inquiries.

The vertebral column of this species, at least in such specimens as have come under my observation, does not appear to be marked by any very remarkably distinguishing character. The vertebræ are, indeed, thin, but not so much so as those of the last species; the articulations are particularly nicely fitted, and, in consequence, the whole column has a very neat and elegant appearance, as may be seen in the representation of this part of the animal, Plate XVI. Fig. 1.

At the superior termination of this column, the vertebræ, for the space of about half an inch, and for about the number of eight or nine, comprised in that space, gradually increase in their diameter, but still retain, very nearly, the same degree of thickness, as may be seen in the specimen, Plate XVI. Fig. 2.

Beyond this point the vertebræ increase in their diameter much more suddenly, have a much larger central foramen, and acquire more than double their former thickness. These vertebræ are generally about six in number, and occupy about twice the length of the former, Plate XVI. Fig. 7. These, when separated, are found to differ very materially from the preceding vertebræ: their inferior surfaces are concave to a considerable depth, whilst their superior surfaces, so far from possessing a corresponding degree of convexity, are, in general, but slightly rounded, and are very frequently quite flat, Plate XVI. Fig. 3. Hence, between each of these vertebræ, a central circular space must exist, deeper in its centre than at its margin; its magnitude, of course, depending on the degree of disparity existing between the opposed surfaces of the united vertebræ.

To these succeeds a body of a different form, in which the general

character of the encrinus, the separation into a pentapetalous form, begins to be displayed. In this body, the inferior surface, like that of the vertebræ, possesses a regular concavity; but its superior surface is formed of five nearly triangular depressions, separated by as many linear projections, passing from the centre to the circumference.

From the form and situation of this body, it may be considered as analogous with those parts which, in the preceding encrinites, I have considered as clavicles: the only difference being, that here they are united in one piece, whereas in the former species they exist in five separate pieces. This body, or clavicle, is represented separate, Plate XVI. Fig. 4, united with the vertebræ at Fig. 7, and with the other parts of the animal, Fig. 8, *a*.

That formation of the solid parts, or of the skeleton of the animal, next takes place, which we have already seen adopted, in the preceding species, as preparatory to the formation of the limbs of the animal. Five separate bodies, externally of a rhomboidal form, with inferior surfaces fitted to the superior surfaces of the bodies which have been just mentioned, and with superior surfaces exactly resembling their inferior, form the next series of solid parts, and which appear to answer to those parts which in the preceding species we have considered as scapulæ. These are represented, Plate XVI. Fig. 8, b. where it will be also seen that, in the centre of the side of one of these, a foramen, and in that of another, a projection is observable, showing that from these parts articulated processes had been given off, in the same manner as from some of the trochitæ already noticed.

On the superior surfaces of these last-described bodies are placed five others, which are the first series of those which may be considered as forming the arms of the animal. The inferior surface of each of these bodies forms an obtuse angle exactly agreeing with the angle formed at the union of the preceding bodies, and in which angle these bodies are disposed, whilst the superior surface is regularly

concave. In the concavities of these are placed another series of five other bodies of a similar form, whose inferior surfaces possess a degree of convexity, which adapts them for reception in the concavities of the former bodies, and whose superior surfaces, like those of the former series, are regularly concave, Plate XVI. Fig. 8, c.

In these concavities are placed five other bodies, being the last series of those which appear to form the arms. Their inferior surfaces are convex, fitted to the cavities which receive them; and their superior surfaces are each divided by a ridge, into two pits or concavities, Plate XVI. Fig. 8, d. which are more distinctly seen in the specimen, Plate XVI. Fig. 6. These appear to have been the articulating surfaces of other bodies which have not been preserved, but which may be presumed to have been the articulated fingers of the animal, analagous to those which are seen to exist in the lily species.

From the regular diminution of size in the three last series of bodies, the part of the skeleton which they compose becomes contracted, and the whole mass assumes somewhat of a pear-like shape; a circumstance which may be employed for distinguishing this species, as I have presumed to do, by the designation of the Pear Encrinite.

Although this species differs so much, in form, from the lily encrinite, yet the analogy existing between their component parts is very close. As in that, so in this species, those parts exist, which, from their serving to unite the upper extremities to the body of the animal, have been considered as the clavicles and scapulæ: and in both species the five arms of the animal divide and form hands, each consisting of two articulated fingers.

Having taken this view of the structure of the superior termination of this animal, as far as its imperfect remains will allow; and having also found its structure to accord in its general characters with

that of the other species, I shall now proceed to the inquiry respecting its inferior extremity, or organ of attachment.

In the same spot where the fossil already described has been so frequently found, at Bradford, small protuberant masses, of a peculiar nature and form, have for some time been noticed on the surface of the limestone. These masses are evidently of a spathose nature, and their colour is remarkable, being a very dark grey, with so much of a purplish hue, as to have very much the appearance of the purple fluate of lime.

Having obtained, in addition to those which I already possessed, several very illustrative specimens from the Rev. Mr. Townsend, and having purchased several others from different collectors in the neighbourhood of Bath and Bristol, I proceeded to their examination.

Rubbing several of these masses down in different directions, and giving to them the necessary polish, their real nature and their peculiarity of structure became manifest, Plate XVI. Fig. 5, 12, and 14. That they were formed of a continuation of the entrochal column of this species of animal was rendered obvious, by several of the specimens; the same peculiar neatness in the general form of the column, as well as in its crenated articulations, being observable in these, as has been already noticed in the column, Plate XVI. Fig. 1. But if a doubt existed as to the identity of the species to which these several parts belonged, it must be removed by the examination of the column, Plate XVI. Fig. 5, which, with all the properties observable in the preceding column, possesses the particular characters of that substance which is found adherent to the limestone rock, and which may be considered as the pedicle or radicle of this species, and as answering to the astropodium of Lhwydd, and to the *radii stellarum polyactinobolorum* of Rosinus.

In this specimen the same circumstance is observable, on which it was found necessary to dwell so particularly, whilst examining the

inferior termination of the lily encrinite. An effused lymph, or a membranous expansion, appears to have involved this column, in the same manner as was observed in that fossil, as well as in the inferior termination of the turban encrinus; and appears, in the same manner, to have diminished the mobility of its articulations.

The longitudinal section of a somewhat similar specimen, Plate XVI. Fig. 12, shews more plainly the nature and use of this investing part. The vertebral column is there seen surrounded with different layers of this substance, each of which appears to have been formed on the surface of the column, and to have separated, and extended itself by its growth to a considerable distance, at its inferior part, from the column on which it had been formed, whilst it has still closely adhered to the column at its superior part.

A curious fact is here observable: in these membranes, which at different distances surround the vertebral column, crenulated articulations, similar to and exactly concurring with those of the vertebræ, are plainly to be seen. By this curious conformation of the organ of attachment, it is obvious that a more widely extended base was obtained; and in consequence of the points of union being thus increased by so many concentric lines of adhesion, the firmness of the adherence of the animal must have been well secured. From the crenulated articulations which these tunics possessed in common with the vertebral column which they enclose, it is evident that they must have possessed a certain portion of mobility, such, most probably, as would be necessary for the animal to employ at this part: whilst, by the coherence of these tunics with each other, and with the column itself in the superior part of the pedicle, the vertebral column must here have acquired a considerable portion of strength. The longitudinal section of another of these specimens, Plate XVI. Fig. 14, serves to furnish us with a still more correct idea of the mode in which the osseous tunics or membranes were disposed, on the spot to which the animal was affixed.

The peculiar structure of this extremity of the animal is very clearly displayed, in the beautiful polished agatine specimen, from Soissons, which has been divided by a longitudinal section. Plate XVI. Fig. 13.

In this specimen, but particularly in its lower part, the vertebral column itself is seen surrounded by numerous investing tunics. These, at their lower part, are spread out like roots, and are evidently well calculated to fix the animal to his devoted spot, whilst a little higher up these several tunics cohere together, as well as with the column which they include, and having their crenulated articulations exactly concur with those of the included vertebræ, they form a vertebral column, which, having thus acquired a considerable additional degree of solidity, must have evidently been well calculated to form the main support of the animal.

In the several species of encrini which have been hitherto treated of, it was found necessary to notice how very few specimens of their extremities have been found, in comparison with the remains of the trunk of the animal. This, however, is not the case with this species, since both the extremities of the animal appear to be tolerably abundant; indeed, judging from the specimens of this fossil which I have obtained, remains of its superior and inferior parts appear to have exceeded in proportion those of its vertebral column.

The lower extremities of this species of encrinite, we have already seen, have been found in Wiltshire and at Soissons. They have also been found at Pfeffingen, in Germany, but no correct notion respecting them had been hitherto formed.

Mons. le Professeur D'Annone favoured Mr. Walch with drawings for three plates, from specimens in his museum, obtained from Pfeffingen, and which were employed by Mr. Walch in Knorr's elegant work, and illustrated by Mons. D'Annone's observations, which I shall now proceed to notice.* You will, whilst attending to these remarks, be

* Recueil des Monumens, &c. Tome II. Sect. II. P. 119.

soon led, by several coincident circumstances, to discover that the fossils to which the Professor refers are similar to those of Wiltshire, the nature of which I have just been endeavouring to ascertain.

The Professor remarks that many had doubted the existence of ramified entrochi, and had supposed that their apparent branches were corals formed on them, in consequence of the coral-forming polypes having by accident become attached to their trunks. Of this opinion, he observes, he might perhaps himself have been, had not some of these specimens proved to him that these branches were not merely attached to the surface of the column, but had actually proceeded from its interior part. The crenulated articulation, one of the essential characters of the entrochi, he observes, was discoverable in these ramifications, which convinced him that the matter of which these branches were formed had not been applied accidentally to the surface of the column, and satisfied him that these were ramified entrochi, and parts of some zoophyte of the family of encrini.

The first specimen, represented Tab. G. II. Fig. 1, of Knorr's works, is evidently formed of a fragment of the tumid part of the lower extremity of a large pear encrinus, with its proportionally thick investing tunics. This investing part, as well as the part which it involves, bears very plainly the marks of the crenulated lines of articulation; and as plainly, also, manifests its laminated structure. So evident is this latter circumstance, that Mons. D'Annone, who compares its lamellæ, so regularly disposed on one another, to the coats of an onion, is inclined to think that these concentric rings bear some analogy to those which mark the successive annual increase of trees. The circumstances here remarked are particularly obvious in Tab. G. II. Fig. 4, of the above work.

In one of the specimens of Prof. D'Annone, the entrochus, after dividing at its base into five branches, is spread along the surface of, and imbedded in, the calcareous stone, in such a form as to give at once the idea of its being the radical or foot-stalk of the encrinus. *(Astropo-*

dium encrini.) Mr. Walch is induced, from this extension of its branches along the lime-stone, to consider it as a particular species, and, from this property, to term it *Entrochus Ramosus repens.*

One similarity between the fossils of Pfeffingen and those of Wiltshire, and which may be implied from the colouring of the plates which represent the former in Knorr's work, deesrves to be particularly noticed. The artist, who has executed his part with great fidelity, has thrown a purple tinge into the specimens from Pfeffingen, which, I well remember, when I first saw, appeared to me to be gaudy and unnatural; but, as has been already observed, this same purplish tinge characterizes the specimens found at Bradford, and gives to the spathose matter very much the appearance of purple fluor.

The resemblance between the fossils of Pfeffingen and those of Bradford extends still farther. The entrochi of both places agree in a peculiar characteristic neatness in their form, and particularly in the neatness of the line of articulation, resulting from the fineness of the radiating striæ, which mark the surfaces of their trochitæ. So exact is this agreement, that there is not a doubt, that any one who was acquainted with the forms of different entrochi, but who had not seen those of Pfeffingen, would, immediately on seeing the figures of these, in the work of Knorr, have named them for the entrochi of Bradford.

LETTER XXI.

NAVE ENCRINITE.....DISCOVERED IN YORKSHIRE BY MR. MARTIN LISTER.....IN GLOUCESTERSHIRE BY MR. JOHN BEAUMONT.....SUPPOSED TO BE THE RADIX OF AN ENCRINUS....SHEWN TO BE THE PELVIS OR SKELETON OF THE BODY PART.....SIMILAR FOSSILS DESCRIBED.....OTHERS FROM THE ISLE OF GOTHLAND.....ENCRINITE IN MR. DONOVAN'S COLLECTION.

In the year 1674, Mr. Martin Lister discovered, in Braughton and Stock, little villages in Craven, in Yorkshire, stony bodies which he considered as the *radices of entrochi.** Having referred to the passage of Agricola, noticed in a former letter, in which he speaks of the *Radices Entrochorum*, Mr. Lister says, " we, in these rocks, find certain rude stones, of the bigness of walnuts, which have many impressions of trochitæ upon them, as though they had been the *roots* of them :" and proceeds to observe that all these stones are not to be considered as *Lapides informes;* instancing to the contrary, the encrinital remains, to the consideration of which this letter is devoted.*

These fossils, he describes as being about the size of a walnut, but in the fashion of a pine-apple or cone, with a hollow bottom, sur-

* Philosophical Transactions, No. 100.

rounded by five double points or feet, in the figure of crescents, and having on their top the impression of a trochites, or a trochites itself yet adhering. He describes these stones as incrustate, from their being covered with rough polygonal plates, and says, " I can compare the incrustation of these stones to nothing so well, as to the skins of the *piscis triangularis*, thus described by Margravius: " Cujus cutis (nam caret squamis) figuris trigonis, tetragonis pentagonis, hexagonisque mire distinguitur et notatur."

Mr. John Beaumont relates, in the Philosophical Transactions for the year 1676, that the bodies termed *radices*, by Mr. Lister, were to be found in the Mendip Hills, Gloucestershire, and says, " Agricola compares these stones to a wheel; and truly the body well resembles the nave of a cart or coach wheel, the shape of it being conical towards one end, till you come just to the top, where it is a little flat, with a hole in it; and it has another hole in the middle of the broad end, opposite to this, very fit for an axis to pass through, and the five hollow stirts or feet, issuing sideways, at equal distances from the broad bottom, somewhat resembling spokes; the said stirts standing about half an inch out from the body of the stone, so that it may not very improperly be called *Modiolus quinque radiatus;* and at the ends of the stirts, where the hollows should show themselves, there grows, after a very artificial manner, a pretty large seam of the same stone, just over the middle of the hollow, from the upper part of the stirt to the lower part of it, parting the hollow in the middle, and covering about a third part of it, not that this seam enters farther into the hollow than the mouth of it, so that the hollow of each stirt presents itself with two eyes. Hence, it appears that those stirts or feet were never longer than they are, and that no stone ever grew to them."

Mr. Lister says " the feet were like crescents at the end, whereby I find the fore-seams of his stones were broken off, as two of them are in mine. The stone seems wrought all over like the fish mentioned by Mr. Lister, being composed of trigonal, tetragonal, pentagonal,

and hexagonal plates. The upper part of the conical end is wrought round with six large hexagonal plates, and these reach half-way the stone; then follows a second round, made up of eleven pentagonal plates, pretty large, and these reach almost to the broad bottom, which is a little convex, the bottom itself and feet contain plates of all makes, but most of them are very small."

Mr. Beaumont calls them, with Mr. Lister and Ray, Rock Plants, and adds, " we may truly say that there have been and are whole fields or forests of these in the earth, as there are of coral in the Red Sea."

" I must own (Mr. Beaumont says) the knowledge of its being a radix to Mr. Lister's hint, though I have Agricola by me, but did not well mind him; and because the perfect *radix* was smooth on the top, and many other pieces of radixes which I have by me, they did not well indicate the thing, though upon a review I find one of them with small rays there." Mr. Beaumont thus designates the particular fossil, of which he has given a figure. " A curious radix, somewhat more entire than elsewhere to be found, on which those rock plants sometimes grow, though it be manifest that they often grow also from plain roots."*

Both Mr. Lister and Mr. Beaumont have supplied the Philosophical Transactions with figures of these bodies; that furnished by the latter gentleman being exceedingly correct. But entertaining a direct contrary opinion respecting this fossil, from that which these gentlemen were led to adopt; believing that, instead of its being the base or radix of the entrochus, it is the summit of the column, or the pelvis, from which the arms, fingers, and tentacula of the animal proceeded, and which was supported by the trochital column, it became necessary to represent it in a reverse position to that in which it had been placed in those figures. I therefore availed myself of the polite and prompt assistance which I have always received during my re-

* Philosophical Transactions, Vol. X.

searches, from the officers of the British Museum, and procured a drawing from, I believe, the identical specimen described by Mr. Beaumont, and which now makes a part of that superb collection. The representation of this fossil is at Plate XVII. Fig. 3, where at *a* is shewn the surface which was applied to the superior termination of the vertebral column, which supported the pelvis or visceral cavity, from which proceed the five hollow arms, each dividing into two, whence, I suppose, proceeded the fingers, tentacula, &c.

To enable me to shew you the grounds of this supposition, I must place before you a few other fossils, the examination of which will, I trust, lead you to agree with me in the conclusions I think myself authorized to make. I lament the being unable to determine where these fossils were found; but this circumstance, however to be regretted on other accounts, will, fortunately, in no respect interfere with my present object. It is right to observe that, from the similarity of their matrix, and, from my having obtained them all from one person, there is reason for supposing that they all came from the same place, and I suspect from the Isle of Gothland.

One of these fossils, Plate XVII. Fig. 4, although very imperfect in some respects, retains sufficient of its original form and matter to prove that it is of the same species with the fossil just described. Like that fossil, it has a small circular radiated area at its lower part, evidently adopted for articulation with the superior vertebra of the vertebral column; and, like that fossil, it had five hollow arms, each divided by a partition down the centre. This fossil is entirely filled with a very hard pyritous clay.

Another, Plate XVII. Fig. 2, is a fragment of either a variety of this species, or of a much larger specimen than those just described; it has a trochital articulating surface, nearly six times as large as that of the former, with a central pentagonal opening. This surface appears to have been formed by a circular plate, with five obliquely

raised triangular processes, between each two of which is placed a pentagonal plate, about a quarter of an inch in thickness.

The small one, represented Plate XVII. Fig. 5, exactly agrees, in every respect, with a fossil which is in the British Museum, in the same box with the one already described in the words of Mr. Lister and of Mr. Beaumont. Like that fossil, this smaller one has its trochital articulating surface, its five arms, and its surface made up of polygonal plates; but it has no opening on the upper surface. On this part, instead of the opening which is observable in Mr. Beaumont's fossil, there are six round protuberances of different sizes; one projecting about an eighth, and the other about the thirty-second of an inch. The articulating surface in this fossil is very indistinctly seen: it appears to be formed of three pieces, the form of which cannot be positively ascertained. Around these are disposed six hexagonal pieces; on which other smaller ones are placed, forming the visceral cavity; but the form and arrangement of these cannot be well made out.

The fossil fragment, Plate XVII. Fig. 1, is particularly interesting on several accounts. The crenated articulating surface is very distinctly observable on it, especially towards the edge of the circle. It is also distinctly perceived that this articulating surface is formed by the union of the flat surfaces of three hexagonal ossiculæ, the commissures of which are not, however, discoverable on the articulating surface, in consequence, as it appears to me, of a portion of the intervening cartilage still remaining adherent on the articulating surface.

The ossiculæ in this fossil, having a more rounded external surface, appear more separated than those in the preceding specimens, and are therefore more distinctly seen: their edges, when viewed with the assistance of a lens, display an osseous structure, very much resembling that which is seen on the edges of the fossil bony palates of fishes.

Around the three hexagonal bodies, forming the articulating surface, is a series of six other hexagonal bodies, which are articulated with the former; four of these bodies are shewn in the figure; the other two cannot easily be shewn in this view of the specimen. To these, another series of smaller hexagonal bodies appear to have been united, four of which now only remain. It is impossible to determine from this fossil, in its present state, what was its original complete form; but, as far as can be judged from the arrangement of the few remaining ossiculæ, it may be concluded that its form was somewhat similar to that of Mr. Beaumont's, Plate XVII. Fig. 3. This conclusion will, I think, be strengthened by the examination of some other fossils, which have hitherto been too little regarded.

Subjoined to a letter of Dr. Capeller to Scheuchzer, on the study of Lithography, &c.* are figures of three different encrini, which appear to be referable to the species just treated of.

These are described as Stony Gothlandic Encrini or Stars, with articulated rays or fingers, and *ossiculæ* like carpal bones, proceeding from the extremity of the trochitæ, different from any encrini hitherto known.

One of these, here represented, Plate XVII. Fig. 10, taken from Fig. 3, of Dr. Capeller's plate, very much resembles, in its carpal part, the fossil figured Plate XVII. Fig. 1. The figure from Dr. Capeller's plate, besides pointing out the similarity between that fossil and the fossil in my possession, figured above, Fig. 1, serves also to shew that the encrinite, described by Mr. Lister and Mr. Beaumont, are also of a similar kind. The fossil remains, which I possess, are sufficiently similar, in their trochital articulating surface and general form, to evince their affinity with the English fossils; whilst the disposition of the metacarpal ossicu æ of the one, at Plate XVII. Fig. 1, makes out the relationship of both with the Gothlandic encrini of Dr. Ca-

* Epistola ad J. J. Scheuchzerum, 1729.

peller, and, of course, the general agreement of these fossils with each other.

The figure of Dr. Capeller's fossil is useful also on another account. Articulated tentacula are seen passing from the inside of the fingers, plainly evincing that these fossils are the superior terminations, and not, as Mr. Lister and Mr. Beaumont supposed, the *radices* of encrini. The form of the fingers of the encrinus, figured by Dr. Capeller, so much accords with that of the fingers of the encrinus in Mr. Donovan's Collection, and which I shall next notice, as to induce me almost to think that Mr. Donovan's fossil may be of the same species with those which have been just examined.

One of the encrini figured by Dr. Capeller differs from the rest sufficiently, to allow it to be considered as a variety of this species; the metacarpal ossiculæ being so thickly and deeply radiated, as to give to each of them somewhat of a roselike form.

The fossil figured Plate XVII. Fig. 12, is a small specimen, apparently of this species, which is in the British Museum. The only account of this fossil which I could obtain, is that which is contained in the label accompanying it, describing it, "Modiolus galeatu , from Benbuisghen, a high mountain near Murlach Môr, in the county of Sligo."

I am at present unable to offer any opinion respecting the nature and form of the trochital trunk of this animal, or of its inferior extremities. I, however, hope that, having traced it thus far, I shall learn, before long, that some other admirer of these subjects, resident in the neighbourhoods in which they are found, will have more successfully extended this investigation. Then, and not before, can this animal be designated by an appropriate name; at present, it may be proper to term it, agreeable to the resemblance which it bears to the nave of a wheel, the Nave Encrinite.

In the very valuable and interesting museum of Mr. Donovan is, I believe, an unique specimen of the remains of an encrinite, which seems to have been nearly intermediate, with respect to the length of

the fingers, and of the tentacula, between the lily encrinite and the Briaræn pentacrinite: these partaking of the great length of those in the latter fossil; whilst, like those of the *Lily Encrinite*, they appear to have been capable of being contracted into the form of a closed flower. The arms and fingers are much more slender than in the lily encrinus; and the articulated tentacula, which are arranged along the whole length of the fingers, have very much the appearance of the terminations of the abovementioned pentacrinite. It is much to be regretted that the parts forming the pelvis are not discoverable in this specimen; in consequence of which, no correct opinion can be formed, respecting the modes in which the arms were given off from the pelvis, or of the manner in which this was united to the vertebral column. For a particular account of this curious fossil, I must refer you to the subjoined information respecting it with which I have been favoured by Mr. Donovan.

" PLUMOSE ENCRINUS.

" A large flat piece of compact grey limestone, of nearly a triangular form, and very uneven surface, at its greatest extremities, 10 inches by $8\frac{1}{4}$. In one part of this is imbedded an encrinus, having a great number of long arms or rays, each furnished with numerous delicate tentacula or claspers, disposed like the feathery appendages on the quill of a pen, and on account of which resemblance it has been named Encrinus pennata. Fourteen of these arms are visible, or may be traced, on one side of the stone, and sixteen or more on the other. Some of these arms, being *in relievo* on the surface, shew the tentacula very distinctly and fine; others are partially concealed in the stone. Near these are a number of the finer or extreme parts of other arms of a similar structure. The arms are cylindrical, and composed of a great number of flat joints with a rounded edge, the largest about

one-eighth of an inch in diameter, from which they taper, in regular gradation, to a point; the tentacula consist of many articulations. The main stem seen in this mass is of a circular form, somewhat hollow within, having the edges rounded off, and a small hole in the centre. There were several fragments of branched madrepores, and striated shells of the anomia genus, also imbedded in the stone."

From Dudley, in Worcestershire.

LETTER XXII.

THE TORTOISE ENCRINITE....THE STRAIGHT ENCRINITE....THE BOTTLE ENCRINITE.....THE CLOVE ENCRINITE.....KENTUCKY ASTERIAL FOSSIL....UNCOMMON ENCRINAL VERTEBRÆ....FOSSIL, APPARENTLY AN OVAL ENCRINITE.

THE first mention which I find made of any part of the extraordinary fossil, which, from the disposition of the plates of which it is formed, may be termed the TORTOISE ENCRINITE, and whose nature I shall now attempt to investigate, is in Mr. Lister's paper on the *Radices Entrochorum*,* already noticed. He there gives an engraving of one of the plates of this animal, which he describes only as "a pentagonous plate embossed with angles."

One of these plates, from the chalk-pits in Kent, is exhibited, Plate XIII. Fig. 30, adhering to its chalky matrix. A considerable degree of variety is observable in the markings on these scales; those which are seen on the scale here figured, showing, from their extreme irregu-

* Philosophical Transactions, No. 100, February, 1674.

larity, how difficult it is to describe them in words. In general, however, the markings are made by lines passing perpendicularly from each edge of the plate, and terminating in radiating lines extending from the centre of the plate to each of its angles. These markings not only differ very considerably in different specimens, thereby forming numerous varieties; but, as will be presently seen, they vary in the different series of the plates in the same specimen, being adapted, in some measure, to the different forms of the plates; which also vary in their respective series, by which their better adaptation to each other is secured, and the required form of the animal is obtained. Their connection with each other is also secured, by their rays or markings so terminating at the edges of each plate, as to form crenulated margins, which are reciprocally received into each other.

In the specimen of this animal, Plate XIII. Fig. 24, from a chalk-pit, in Kent, its inferior part has evidently been formed of five pentagonal plates, circularly disposed, two of which are seen in this view of the fossil, with a semicircular notch in the middle of each inferior margin. The surfaces of these plates have but few markings; four or five risings only passing from the centre of each plate, and meeting at each articulation with similar risings in the adjoining plates.

In the five angular recesses which result from the junction of these bodies, at the upper part are placed the corresponding projecting angles of the next series of five hexagonal plates; and in five superior angular recesses, formed by these, are placed the corresponding projecting angles of the third series, which are all pentagonal: each of these having its superior side articulated with one of the sides of a pentagonal plate at the top, which completes the marsupial form belonging to this animal.*

* This description is adapted to the annexed figure, which is, by mistake, placed in a reversed position to that which was, perhaps, most common to the animal; the close part of the purse at the bottom, and the open part from which the tentacula proceeded, at the superior part, as in the description by Mr. Donovan.

As Mr. Donovan possessed a more perfect specimen of the fossil remains of this animal, than I could procure, I requested and obtained of him the following accurate description from the ticket which accompanied his specimen.

"The *Tortoise Asterio Encrinus*, an animal partaking of the nature of marine crustaceous creatures. It is composed chiefly of sixteen angulated pieces or plates, of which five pentagonal ones surround the mouth, in the upper edge of each of which is a semicircular notch, from which depends a jointed arm or tentacula, which is dichotomous after the first two joints, and is probably again divided and subdivided towards its extremities. Those arms were, no doubt, designed by nature to assist in taking its food. Immediately under these five plates are five other hexagonal ones; and below these, five more that are pentagonal, and the bottom is terminated by a single pentagonal plate. All the plates fit closely into each other in the same manner as the scales of a tortoise, so that no interstices appear, and these are radiated from the centre to the edges; the upper plates with four or five rays each, the rest with six rays each: from the sides of these ridges proceed lesser ones, terminating at the edge, and giving them a pennate appearance. The plate from which the branched arms proceed, are not so much striated between the larger rays as the other. In some plates, the striæ are broken, and form a rugose surface. The plates vary in their markings in different individuals, and even in the same specimen, some are coarsely ridged, or rayed; some finely ridged, or rather striated, and some are nearly smooth. The body does not seem capable of extension. Found in a chalk-pit, in Surrey."

Mr. Ingham Forster's *Museum*, O. 98.

Whilst attending to the forms, as well as to the different markings of the plates of which this animal is composed, you will not fail to observe some similarity with those of the encrinite just examined, and designated by the term Nave Encrinite. One material difference,

however, exists between these: in that encrinite evident marks are seen of its having been attached to a vertebral column; whilst in this (the tortoise encrinite), there is no trace whatever of any mode in which such a combination could have been accomplished.

Mr. Donovan's specimen is rendered particularly interesting by the two first bones of one of its arms being still adherent to one of the semicircular openings, and in such a manner as not only to show that its divisions were dichotomous, but also to furnish us with some slight intimation of the nature of the trochitulæ of which this member was formed. The articulating surface of one of these may be seen to be evidently formed by a slight concavity, in the centre of which is a small foramen: two ridges, with a narrow intermediate depression, passing in a line from this foramen to the two opposite points in the circumference: this articulating surface closely resembles that of the fossil trochites depicted Plate XIII. Fig. 40. But even with this aid, I must acknowledge that my researches respecting the arms and tentacula of this animal have been entirely unsuccessful.

Whilst striving to connect bodies together to form the ramifying arms of this animal, I however discovered two other species of encrinites, possessing similar articulating surfaces with those of the ossiculæ of the arms of the tortoise encrinus, which I shall now proceed to place before you, with some other substances, which bear generic marks of distinction sufficient to warrant their being considered as belonging to encrinites, although not always sufficient to admit of their being respectively connected, so as to make out their respective species.

Following the particular character of the articulating surface of the trochitulæ attached to the body of the tortoise encrinite, I first call your attention to a fossil body, frequently found in the Kentish chalk-pits, which is of a cylindrical shape, and has at its ends two articulating surfaces, much resembling that which is observable on the ossiculæ attached to the tortoise encrinite. One of these bodies is represented on its matrix, Plate XIII. Fig. 35. Its surface is smooth, and

the articular ridges, which at each end traverse its axis, cross each other, passing in opposite directions; as is also the case with the trochites, Fig. 41.

With the hope of learning more of the animal to which this part belonged, I sought for some body which, with a similar articulation, possessed some variation of form, and at length discovered the body, Plate XIII. Fig. 34, which is also attached to its matrix. These bodies are found in the same chalk-pits as yield the bodies just described. At the one end of this body exists a similar articulating surface with that of the former body; but at the other end, such a conformation is observable, as seems plainly to mark it as the base of the pelvis, from which the arms of the animal had proceeded. Five pentagonal pieces are first disposed in a circle on the end of the trochite, and on these are placed five other pieces, which are rather longer than the former. An inferior angle of each of these is let into an angular recess, formed at the junction of each two of the former bodies; and at their superior part, each of these bodies terminate in a concave surface, with two denticulæ on its interior margin, forming, at their union, a surface, which bears very much the appearance of a flower with five petals. From this surface must have proceeded the arms, fingers, &c. of this animal; to discover the structure of which was the next object of my research.

Following the clue yielded by the particular species of the articulation, I am led to place next before you, as parts, in all probability, composing the articulated arms and fingers, the series of ossiculæ, Plate XIII. Fig. 70, which are here depicted rather beyond their natural size. These, from the resemblance which their articulating surfaces bear, appear to be deserving of being classed with the preceding body. The middle part of these ossiculæ is cylindrical, but the ends are contracted, as if compressed, in two contrary directions, so that two narrow elongated surfaces are formed at each end, exactly crossing each other, and having a ridge running the length of

these surfaces, by which they articulated together, similar to the articular surface of the former bodies. Pursuing the examination of these bodies, through the different sizes which I possess, I found others of a smaller size, as at Fig. 71, and at last arrived at a soliary specimen, Fig. 72, which is evidently one of the terminations of this series. Thus we discover the superior termination of an encrinite, entirely different from any which we have yet seen, and which appears to be rather referable to some species which has been hitherto totally unnoticed, than to the tortoise encrinites, to which, from the peculiar mode of its articulation, there seemed at first to be reason for supposing that it belonged.

That it does not belong to that animal is, indeed, rendered almost certain, by the fortunate discovery of the small illustrative specimen, Plate XIII. Fig. 73, where a vertebra, with an articular surface similar to those we have been describing, is seen to proceed from a flat, expanded, and ramifying base, which, on its inferior part, has every appearance of having adhered to some other body, and which, therefore, may properly be considered as the pedicle of this animal. Of this small species of encrinite we therefore seem to possess the organ of attachment just described, the vertebræ, the pelvis, and the ramifying superior extremity. The only peculiar character by which it can be distinguished from other species, appears to be the straight manner in which the ossiculæ are disposed, of which its pelvis is formed. From this circumstance I am led to distinguish it by the appellation of the Straight Encrinite.

Pursuing the examination of such bodies as are characterised by this particular species of articulation, I was led to the examination of the spathose vertebra, Plate XIII. Fig. 74. This fossil, which was also imbedded in chalk, is barrel-formed, having a similar articular surface at each end with the fossil just treated of, the surface of its sides being finely granulated: but in some of these bodies, this surface is tuberculated or even rugose, and in others nearly smooth.

Whether these differences on the surfaces of these bodies are the differences of varieties only, I am unable to determine, from any of the specimens which I possess. Nor am I able to point out, with any degree of certainty, any of the other parts of the animal to which these vertebræ have belonged. I have, however, very little doubt, that they served to constitute the vertebral column of the animal, the body part of which is represented Plate XIII. Fig. 75 and 76.

This body of an encrinite, Fig. 75, gradually enlarges from its articulating surface, and assuming somewhat of a tumid utricular figure, terminates in a superior floriform surface, on which are five triangular depressions. By the assistance of a glass, this body part may be seen to be divided into ribs, clavicles, and scapulæ, very much in the same manner as is done in the straight encrinital body just placed before you, Plate XIII. Fig. 34. At Fig. 76 is represented another of these fossils, in which the first vertebra is still adherent to the body part, a very fine, somewhat raised line, marking the union of the vertebral column with the pelvis. The utricular form assumed by the body part of this encrinite has disposed me to name it the Bottle Encrinite: the workers in chalk also distinguish these bodies by the term *chalk-bottles*.

Hence it appears, that two other species of encrini must have existed, the articulating surfaces of whose vertebræ bore a very close, if not an exact, resemblance with the ossiculæ of the extremities of the tortoise encrinite.

The next objects of research were the fossils corresponding with those just described, in their tuberculated, granulated, or rugose surface. This inquiry terminated in only ascertaining that there existed a species of encrinus, whose vertebræ, represented Plate XIII. Fig. 69, bore on their sides these peculiar markings: these trochitæ differing, however, essentially, from the vertebræ of the preceding species, by radiated or trochital surfaces of articulation, and by being pierced with a much larger foramen.

The three specimens of encrinital remains, still adherent to their chalky matrix, Plate XIII. Fig. 31, 38, 39, decidedly belong to a species entirely different, especially in its mode of ramification, from any which have been hitherto noticed.

The curious mode in which the ossiculæ are articulated in these specimens is particularly deserving to be remarked; it is therefore carefully made out in the specimen, Fig. 31, where the form of the arms seems to warrant the appropriating to this species of encrinite, the appellation of the STAG'S-HORN ENCRINITE.

The calcareous fossil, Plate XIII. Fig. 77, with an extended flat base, gradually assumes a columnar form, and terminates upwards in a small round crenulated surface, pierced with a hole which passes through the substance of the fossil. There can be little doubt, that this fossil has been the organ of attachment of some minute animal of the genus encrinus. This is confirmed by the appearance of its under part, which shows no fitness for motion, but appears to have been well formed for securing its adherence to any other substance.

The probability of this conjecture being correct is increased by the appearances yielded by the next fossil, Plate XIII. Fig. 78, which is a small, long, slender, trochital vertebra, agreeing so nearly in its size, colour, and articulating surface with the preceding fossil, as to give strong reason for supposing that a series of these formed the vertebral column to which it served as pedicle.

The fossil represented, Plate XIII. Fig. 79, has been long noticed by oryctologists for its close resemblance in form to a clove; from which circumstance it derived the name *Caryophillus lapideus*, which is in general applied to it. Various have been the opinions entertained respecting it, some having believed it to be actually a petrified clove; others, that it was part of the spine of an echinus of a particular form. Lhwydd seems to have been the first who entertained a rational opinion respecting its origin. Referring to a specimen which he had received from Germany, and to the only specimen which he had

met with, and which he had found in Caldey Island, he says, " At originem, si attendamus, non aliud revera est, quam stellæ cujusdam fossilis modiolus."*

These fossils are found in great numbers in the mountains of Switzerland, particularly in those of the Canton of Zurich, and of Schaffhausen. The form which they bear certainly approaches very nearly to that of a clove. The lower extremity is pierced in its centre, with a small opening, which is surrounded by a crenulated surface, fitted for articulation with a trochital vertebræ. From this termination the body of the fossil gradually enlarges, and is so extended, as to terminate in five points, with five intermediate circular margins; and to form, in the upper part, a slight concavity, answering to the pelvis in the larger encrinites, with a relieved stellated figure in its centre. In each of the circular margins are two depressions, in which, in all probability, were fixed the first ossiculæ of the arms of this animal. Viewing this body with a lens of tolerable power, it is seen, that a suture passes from each of the five points, just described, through the centre of the inferior extremity; dividing this body into five ossiculæ, as we saw was the case with the Ossa Innominata of the lily encrinite. That this, agreeable to the opinion of Rosinus, is the central part of some species of encrinites, not yet known, is all that can at present be asserted of it. With respect to its vertebræ, it is observed by Mr. Walch, that one of the barrel-formed trochitæ has been seen attached to the articular surface of this body. This observation encouraged me to offer a conjecture that it may be the pelvis belonging to the barrel-formed vertebræ, Fig. 78, last described; the organ of attachment belonging to which, I have ventured to suppose, was the body represented Fig. 77. This opinion being correct, the appellation of THE CLOVE ENCRINITE appears to be applicable to this species.

* Epistola ad Augustum Quirinum Rivinum.

To future discoveries must also be left the ascertaining of the original nature of the other fossils which remain to be noticed in this letter. The first of these, Plate XIII. Fig. 80, claims its admission, merely from the floriform figure which it assumes, like the lily encrinite, from the closing of its arms. From the base of this body a neck proceeds, which soon terminates in four arms or claws, in a contracted state. In other bodies, apparently of a similar species, the number of the claws varies from two to even five. There exists no mark in these bodies to determine whether, in their original state, they were attached to vertebral columns, or were occasionally attached to some foreign bodies. These specimens, as well as the former, are calcareous, and were also obtained from the mountains of Switzerland.

This petrifaction is figured by Mons. Bourguet, who describes it as the hexagonal flower of a coralloid *(fleur hexagone d'un coralloide.*)* An examination of the figure of this fossil, which is here given, will sufficiently show that it partakes more of the nature of the encrinus than of the coral; a remark which has been already made by Mons. Davila† and by Mr. Walch. The latter gentleman appears only to have seen it figured by Bourguet, from which representation of it he is unable to determine whether it is jointed or not; and he observes that it is an extremely rare fossil.‡

The ramifying fossil body, Fig. 81, has somewhat of the appearance of the former fossil in an expanded state. Some of these fossils have three, four, and even more branches, expanding in a similar manner. Mons. Davila considers these as, *vertebres noueuses differentes des entroques et qui semblent appartenir aux rayons du sommet de l'étoile;* and in another place he calls them, *des petites articulations branchés des sommets.* Mr. Walch acknowledges that he cannot with certainty say to what substance they belong. When viewed with

* Traité des Petrifications, Tab. XIII. Fig. 70, 71.

† Catalogue systematique et raisonné, Tom. III. p. 194, No. 242.

‡ Monumens des Catastrophes, &c. Tom. II. p. 104.

a magnifying glass, their form and structure is seen to agree very exactly with the ramified arms of the preceding fossil.

The small calcareous fossil body, from the same place, delineated Plate XIII. Fig. 82, is here introduced, in consequence of the ambiguity of its appearance. From the resemblance which its general surface bears to that of the last fossil, it might be concluded to be the detached arm or tentaculum of that animal in an extended state; a smooth circular pit at its inferior extremity renders this opinion not improbable. A magnified representation of one of these bodies is given, Plate XIII. Fig. 83.

The nature of the calcareous fossil, represented Plate XIII. Fig. 36 and 37, is very ambiguous. I was favoured with it by Dr. Woodhouse, of Philadelphia, who, avowing his inability to ascertain any thing respecting its original mode of existence, informs me that it was obtained from Kentucky, where similar bodies are frequently found of a larger size, and that they are there considered as a species of petrified nuts.

This fossil is somewhat of a conical roundish form, the centre of its base terminating in a small round projection pierced in its middle, with a little opening into the centre of the fossil: from this projection the base extends nearly horizontally to five prominent points, between each of which exists a shallow depression. At the apex of the cone five small openings are placed at the angles, formed by the meeting of the lines, which bound five long triangular surfaces, which, commencing at the summit of the fossil, are disposed tapering, down the sides, and terminate in the projecting points which are placed round the base. Along the middle of each of these surfaces, a grooved line passes, from which upwards of forty minute processes on each side pass to the lines which bound these surfaces at their sides.

The opinion which I formed on the first view of this fossil was, that it belonged to some animal approximating to the encrinus. The central projection at its base has, however, suffered so much by friction

as not, I believe, to show its original surface; and hence it is impossible to determine at present any thing respecting the substance with which it was connected at this part, or the kind of articulation which was here employed. It, however, very nearly resembles the smaller *modiolus*, from Ireland, which is represented in Plate XVII.

Among the enigmas which must be left to be solved by the industry of future inquirers, into the original nature of the various species of encrinites, there is no one which appears to me to be more difficult than the determining the original properties and mode of existence of the animal, of which a part of its vertebral remains, in the state of lime-stone, is represented Plate XVI. Fig. 16. Two remarkable circumstances in this fossil must attract your admiration, and, of course, excite your curiosity: the contorted forms in which the vertebral column is disposed, and the remarkable processes which appear to have issued from the sides of the vertebræ.

The first inquiry which naturally arises, on viewing the parts of an animal disposed in a form entirely different from that which any other species of that kind of animal assumes, is, whether or no that position is the effect of accident? To this question I acknowledge that, on the first view of this specimen, I was much inclined to anticipate an affirmative answer. A careful examination into the structure of these fossil remains, soon, however, convinced me that these contortions were natural to this part of the animal, and that the construction here adopted displayed the most admirable instance of the wise adaptation of means to the accomplishment of a proposed end. In the examination of most of the preceding species of encrinites, we discovered that, for the purpose of securing a greater degree of freedom of motion, in that part of the vertebral column which was nearest to the superior extremity of the animal, a peculiar structure was employed ——— the vertebræ were alternately wider and narrower, and the narrower were received into the perpendicularly lengthened margin of the wider; the outer crenulated edge of

the narrow included vertebræ articulating with the inner crenulated surrounding edge or collar of the wider vertebræ. By this contrivance, a degree of flexibility was secured, proportionate to the extent to which the several vertebræ were capable of obliquely moving on each other.

In the specimen now under examination, a similar arrangement is observable through its whole extent. Narrow and wider vertebræ, with the former included in the margin of the latter, thereby admitting a certain degree of lateral motion, and at the same time presenting a check for the prevention of dislocation, manifest a curious contrivance, and leads us to the conclusion that, in this part of the animal, the power of performing this kind of motion was particularly demanded.

To explain the uses of the digitated processes, given off from the wider and larger vertebræ, and which, in its present lapideous state, connects in several parts the opposite windings of the column, I acknowledge myself entirely incompetent. I am equally incapable of forming any opinion with respect to the other parts of this animal; not ever having seen any part which appeared at all to correspond with it, in its peculiar and extraordinary conformation.

How far this last assertion requires an excepting clause in favour of the fossil, Plate XVI. Fig. 9, I will leave you to determine, after having attended to its form and appearance. The fossil is composed of ten vertebræ closely conjoined; each vertebræ having about one-third of its sides covered with a process divided into five denticulæ, which are placed at regular and accordant distances in each vertebra. The other two-thirds of the sides of the vertebræ are very closely beset with small points and tuberculæ, almost linearly disposed, and giving to the surface a very uncommon and indescribable appearance. Indeed, the extraordinary form and contour of the whole fossil is so difficult to describe as to render a reference to the annexed figure indispensably necessary to its comprehension. Except-

ing the slight resemblance which it bears to the preceding fossil, I do not know a single instance in which I can trace the similarity between it and any other encrinital remains.

I cannot, however, help concluding that these two specimens, although both possessing digitated processes, are of two distinct species. This seems probable from the much greater regularity in the disposition of these processes, in the specimen Plate XVI. Fig. 9, than in that of Fig. 16: besides that in the specimen Fig. 9, the surface of the trochitæ is very closely punctuated, except immediately where the processes are given off: a circumstance which does not exist in the specimen, Fig. 16. A similar but much handsomer specimen of this species is figured and described in the tenth volume of the Philosophical Transactions: the original specimen being now in the British Museum.

The curiously formed fossil body, represented Plate XVIII. Fig. 4, must await the illustration of more perfect specimens to determine whether it should be considered as the remains of an alcyonium or of an encrinus: its form sufficiently characterizes it as a zoophyte; and does, I believe, afford decided evidence of the justness of the opinion which I entertain of its owing its origin to some unknown species of the encrinus.

The whole specimen is formed of a ferruginous, cherty substance, which yields sparks but sparingly with the stroke of steel, and on which the nitric acid manifests no action. I am unable to state where this specimen was obtained from; but from its bearing several impressions of the alcyonite already mentioned, as observable on a specimen supposed to have been obtained from America,* and from other points of resemblance between the two specimens, its being an American fossil appears to be no ways improbable. The substance to which I particularly call your attention is imbedded nearly in the centre of

* Page 150.

the mass : it is of a compressed oval figure, and has its surface marked by numerous longitudinal alternate ridges and depressions. That which appears to have been the inferior part of this body, and which, I suppose, was attached to that part, which, in the encrinus, I have considered as the pelvis, is slightly and irregularly concave, and being a transverse section, its surface is of an elliptical form. On this surface, eight bodies lay parallel with each other in the longest axis of the ellipsis, and eight shorter bodies are disposed on, and almost at right angles with, the external surface of the two outermost long bodies. Each of these twenty-four bodies, at its outward termination, is bifurcated, and thus forms two processes, which pass parallel with each other the length of the fossil. Thirty-two of these, sixteen from each end of the eight longest bodies, and thirty-two from the external terminations of the shorter, making sixty-four of these processes, are thus continued, and form the external surface of this fossil, which is thus marked by alternate ridges and depressions.

Having thus far noted the appearances presented by this fossil, the inferior part only of which, as high as the ridge which marks it transversely, being then seen, the remaining part of it being imbedded in and concealed by the surrounding mass, I ventured to endeavour, by a blow of a hammer, to obtain a more full display of it. The attempt succeeded, and the superior part of it was brought to sight.

By this extended view of its surface, the organization of this body was more fully discovered; and, I think, very strong evidence adduced of its being a species of ENCRINITE, *of an oval form, the trunk of which was composed of vertebræ, which also were oval.* But, although entertaining a strong belief that this is the case, I am aware that farther observations and more illustrative specimens may be required to determine its being so, I shall, therefore, lay before you a farther description of it, with those observations on its structure which appear to support the opinion which I have offered.

In consequence of the more enlarged view which was obtained of

its surface, a very important and, I think, a very decisive circumstance in the structure of this body was discovered. In the superior part of the processes, of the exterior edges of which the abovementioned ridges are formed, numerous transverse separations exist, at the distances of about the thirty-second part of an inch, which appear to be articulations similar to those which occur between the ossiculæ of the fingers of the lily encrinite, and must have given to these parts of this animal a capacity for similar motions with those which were performed by the fingers of the lily encrinus. Considering these parts, then, for a moment, as the fingers, let us trace back, as far as we can, and we find, as has been already noticed, that two of these fingers proceed from each of the bodies, in the inferior part of the fossil; which, therefore, bear, in this respect, a close resemblance to the arms of the lily encrinite. Besides this, we also discover, in those parts of these bodies which form the inferior surface of the fossil, several transverse fissures which may have been the joints by which the extension and contraction of these bodies might have been admitted. Every thing, indeed, in the form and structure of this body serves to shew that, like the lily encrinus, it was capable of being alternately expanded and contracted for the obtaining and the securing of its prey. Whether the digital processes were beset, on their internal part, with articulated tentacula, this specimen will not allow us to discover.

On various parts of the surrounding matrix are oval impressions, which evidently appear to have derived their figures from the oval vertebræ with which the trunk of the animal had been formed. This conjecture receives considerable confirmation from the impression, which is faithfully represented as existing on the matrix by the side of the above described body: this impression having very much the appearance of being produced by the oval trunk of an encrinus, the vertebræ of which must, however, have materially differed from the oval vertebræ, represented Plate XIII. Fig. 32, 40, 41.

LETTER XXIII.

PENTACRINITES....DIFFERENT VERTEBRÆ NOTICED.

Agreeable to the distinction which it has been already determined to adopt, I have first examined all the species of this kind of fossil, which, from their trochital vertebræ, required to be placed among the encrinites; I shall now proceed to examine such as, from their pentagonal vertebræ, may be considered as pentacrinites. These, as far as our limited knowledge of them will allow me to judge, may be described as *the mineralized osseous parts of a zoophyte, which possessed a pentagonal, articulated, vertebral column, from the superior part of which, from five bases, proceeded as many articulated arms speedily ramifying into innumerable smaller branches, closely beset with articulated tentacula, bearing, in the mass, much of a plumose appearance.*

Adopting, as nearly as I am able, the same order in the investigation of these bodies, as was employed whilst examining the several species of encrinites, I shall, in the first place, make inquiry respecting the nature and history of the fossil vertebræ of these animals. Small flat stones have long been found, being angular and almost constantly pentagonal; bearing on their flat surfaces a stellated figure, somewhat resembling the five expanded petals of a flower. To these stones was given the name of Asteriæ, or *Star-stones;* and when

found united by their flat surfaces, like the trochites, and thus forming a prismatic column, they were termed ASTERIÆ COLUMNARES, or *Columnar Star-stones.* To these, branches were found united, which, terminating in bodies disposed in beautiful floscular forms, were termed ENCRINI.

The Asteriæ, or Star-stones, are small, flat, stellular, or pentagonal stones, ornamented, on both their upper and under surfaces, with a star or flower of five rays or petals, formed by very minute ridges, placed obliquely in two curved lines, meeting, either in a pointed or in a rounded form, at their outer extremities, and approaching to, and sometimes meeting each other nearly in the centre of the body, where the marks of a minute circular opening may be seen. These stones have been also termed *Stellariæ and Lapides Stellares*, and by the Germans, *Sternsteines.* The species or varieties of these stones, like those of the trochites, are very numerous; but, in the subsequent inquiry, I shall think it necessary to notice those only which differ essentially from each other.

"Palmati circa Mundam in Hispania, ubi Cæsar Dictator Pompeium vicit reperiuntur, idque quoties fregeris."* From this passage Mr. Walch is disposed to believe that Pliny had some knowledge, if not of the encrinus, at least of the trochites and asteriæ. These words, he thinks, can bear no other meaning than that, on breaking these stones, markings resembling those of the leaves of a palm-tree were discovered: and, therefore, he supposes that the stones spoken of were entrochi or columnar asteriæ, which, on being separated, displayed the markings resembling leaves. This opinion, he supports, by observing that Torrubia, in his Natural History of Spain, informs us that in that country trochites and asteriæ are at present found.†

* Historiæ Naturalis, Lib. XXXV. Cap. 18.

† From some specimens which I possess, from the mountains in the neighbourhood of

The probability that the stones, of which Pliny here speaks, were either trochites or asteriæ appears, however, to have been very slight indeed. In the first place, the marks which are displayed on the surfaces of these bodies do not appear to be such as would be likely to excite the idea of the leaves of a palm-tree: and, in the second place, it appears to be much more probable that such an idea might have been rather excited by stones marked with impressions of some real vegetable substance.

Before the time of Lachmund, who first gave the name of encrinus to the stone lily, it was considered that as the separated entrochus presented the figure of a wheel on its surfaces, so the separated encrinus (columnar asteriæ) gave the representation of lilies. By the term encrinus, therefore, the columnar asteriæ were then designated. Thus Agricola, who speaks of these fossils, says, referring to the columnar asteriæ, "Quælibet veró talis pars quinos habet angulos, latera totidem, utrinque quina lilia, unde pentacrinos Græcé dici potest. Quemadmodum vero entrochus constat ex multis interdum trochitis, sic encrinos ex multis pentacrinis."*

It may not, however, be necessary to notice, in historic order, the opinions which were entertained respecting these bodies, or the various names which were applied to them: I shall, therefore, proceed to the examination of such of these bodies as seem particularly to claim our notice.

A considerable variety is observable in the forms as well as in the markings on the surfaces of these bodies. Some are nearly circular, having a small circular hole in their centre, round which is disposed a pentaphylloidal figure, the spaces between which are filled with fan-

Cordova, it appears that the remains of encrini are there very abundant, and assist in forming a marble of very beautiful appearance; the animal remains, which are nearly white, being imbedded in a ground of a dark red colour.

* De Natura Fossilium, Lib. V. Page 610.

ciful and elegant markings, Plate XIII. Fig. 60. Rosinus describes several varieties of this species of asteriæ, Tab. IV. et V. usque ad classum, M. In some of these species, the petal-like rays obtain somewhat of a curved form; and in others, a flowret is disposed on the centre of the star already mentioned. With respect to their sides, they may be seen to tend in every degree to a pentagonal form. In some the circumference is formed by five slightly curved lines, united at angles hardly perceptible, Fig. 61; whilst in others the curvatures become much greater, Fig. 62; and in some a considerable indentation is formed on each of the five sides; giving to the body an approach to the stellated form, as in Fig. 63 and 65, and increases in different specimens, as in Fig. 64 and 67, until it is found to form the complete five-rayed star, Fig. 66.

All these, as may be seen in the respective figures, differ again considerably, in the form of their rays, and the disposal of their markings. In one species, Fig. 68, these identations, on a margin approaching to the circular, are so sudden, and comparatively so deep, as to give a truncated appearance to the ends of the rays. The margin of this asteria is finely crenated, and being a little raised, the star is imbedded in a small concave depression.

Bourguet describes a species which, instead of being marked with five petals, has five circular holes or cavities, at equal distances round the central foramen.*

Rosinus, Hofer, Wolfart, and others, have spoken of asteriæ with four sides and four rays. The only one of this kind which I have ever seen is depicted Fig. 59. Too little, however, is known respecting asteriæ of this form, to enable us to determine whether this should be considered as marking a difference of species, or that of a variety only. The former supposition, however, appears to be the most probable.

* Traité des Petrifications, Tab. LVIII. No. 425.

The elegant markings with which the flat surfaces of these bodies are adorned are, like those on the surfaces of the trochitæ, calculated to form an appropriate articulation with the surfaces of other similar bodies. By the union thus obtained are formed those pentagonal columnar bodies, which are generally known as columnar star-stones, or *Asteriæ Columnares*, and by some as angular stellated entrochi, *(Entrochi Angulares Stellati).*

These columns derive a considerable degree of variety, from the difference, in structure and size, of the asteriæ of which they are composed, as well as from the order in which they are arranged: their external markings, therefore, differ considerably. These differences have been very accurately described by Rosinus, and shall be here noticed, as closely as appears to be necessary.

In some, as in Fig. 52, the constituting asteriæ are of a similar size and form: the line of articulation is therefore at the same distances through the whole column. See Rosinus also, Tab. IV. B. 1. But in those columns which are formed of asteriæ of different thicknesses, a correspondent difference in the distances will be observable in the lines of articulation, since these will be more or less frequent, as the asteriæ are thinner or thicker: their lines of articulation will also be more or less undulating, as the asteriæ are more or less grooved on their sides.

Fig. 48 and 53 consist of thicker and of thinner columns of asteriæ, alternately disposed. Fig. 49 is formed by the thicker asteriæ so ranging with those which are thinner, and with those which are of the thinnest kind, that between two of the thicker are placed two of the thinnest, between which is placed one of a medium thickness. Rosinus describes several varieties of this species, depending merely on the different degrees of thickness in the thinnest asteriæ, and in the degrees of fineness in the crenulated markings in the line of articulation.

Fig. 51 represents a columnar series of round asteriæ, and composed of thick, less thick, of thin and of the thinnest asteriæ, so disposed,

that one of but medium thickness is placed between two thin ones, which again are comprised between two of more than ordinary thickness, the thinnest of all being interposed between each of the preceding articulations. Round the thickest of these asteriæ are placed five little pits, evidently intended for the insertion of lateral processes.

From similar changes in the arrangement of pentagonal asteriæ, from the intermixture of those differing in thickness, and the disposition of their ornamental protuberances, great variety arises. Some specimens are figured by Rosinus as being remarkable, from their asteriæ being joined together in an anomalous manner; the lines of articulation, in some, assuming somewhat of a spiral twist; whilst, in others, additional lines appear irregularly to intersect and divide the asteriæ in various directions. Some of these differences appear to be the effect entirely of injury from violence, inflicted either during the life of the animal, or whilst passing from the animal to the mineral state; but others may properly be regarded as sports of nature.

The sides of the asteriæ, forming the column, Fig. 54, is marked on its sides by transverse lines of points, gradually diminishing in size, from the centre of the line, and differing in their length, and even their arrangement, in different columns. In the column, Fig. 55, each star-stone is adorned by a line of minute projections, placed on each angle of the star, and extending each way about one-eighth of each side. The whole surface of the column is thus made to assume a richly embossed appearance, to which the conspicuous appearance of the crenated line of articulation much contributes.

The column, Fig. 56, has a still more elegant appearance. The pattern of its ornament may be seen to comprise five of the asteriæ; the uppermost, lowest, and most projecting of which are encircled by a line which, swelling boldly in the middle of the sides, terminates in a round point on the angles themselves. Next to each of these is an

asteria which does not project, but which is ornamented on its sides by round points disposed in the form of a flowret, and on its angles by single round points. These include another asteria, which partakes, but in a less degree, of the ornaments of each of the preceding. It is encircled by a line which does not project, nor swell out, as in the first described, but it is ornamented with a flowret somewhat similar to, but not so large, as that which is to be seen on the asteriæ which are next to it.

The column, Fig. 57, has a neat as well as a rich appearance, in consequence of being composed of asteriæ, the angles in some of which are more acute, and the intervening recesses greater than in others. In the column represented Fig. 58, a very neat form is observable: the column is composed of similar asteriæ, possessing considerable indentations on their sides, the column being characterized like the one Fig. 52, by foramina in the angular recesses of the column, in the line of articulation.

The entrochus, Plate XVI. Fig. 10, has some resemblance to the one represented Plate XIII. Fig. 55. It is rendered interesting by the form and appearance of its superior part; a depression being there formed on every one of its five sides, in which were deposited the first ossiculæ of the vertebral processes which were there given off.

LETTER XXIV.

BRIARÆAN PENTACRINITE.......VERTEBRAL COLUMN......VERTEBRAL PROCESSES.....TWOFOLD OFFICE.....BONES FORMING THE PELVIS.... SUPERIOR EXTREMITIES......ANASTOMOSING PENTACRINITE.

The species of pentacrinite which first demands our attention is the one which most abounds in this country. This circumstance, and that of its being the species which has been longest known to oryctologists, give it a fair claim to this preference. The distinguishing characteristic of this species appears to be *its vertebral processes passing out from every part of its column.*

In the trunk of this animal are several circumstances of a very interesting nature. The constant intermixture, in various ways, but chiefly in an alternate order of thicker and thinner vertebræ, is observable, I believe, in most of the specimens of this fossil: but so nicely are these vertebræ arranged and fitted, that, except where they have been displaced by accident, they always seem to preserve an exact linear regularity. It is not, indeed, common to see any well connected column of this species detached from its matrix, but in no one specimen, however long it may have been, have I ever seen the least diminution or tapering of the column. This last-mentioned circumstance is particularly deserving of attention, since from it may

be inferred the vast length to which these vertebral columns may have been extended.

In that part of the vertebral column of the lily encrinus which approaches to the pelvis it was shewn that a greater power of motion was given by a peculiar arrangement of the vertebræ; whilst security from dislocation was also obtained by the lapping of the edges of one vertebra over those of the other. In this animal a still greater latitude of motion must have been yielded, by the extreme thinness, and, of course, greater number of the vertebræ in this same part, as is seen Plate XVII. Fig. 15: whilst a similar formation of the vertebræ is observable for the prevention of dislocation; this appearing to have been also guarded against, by the peculiar arrangement of those parts which we shall next examine. These parts are the articulated vertebral processes which, as has been already observed, proceed from every part of the vertebral column.

Plate XVII. Fig. 16, shews the appearance yielded by these curiously formed bodies, as proceeding from the vertebræ. A single ossicula of which, of a rhomboidal form, from that part of these processes which is nearest to the vertebræ, is shewn, Plate XVII. Fig. 14, of its natural size, as well as slightly magnified. In these figures are also seen the flat surfaces by which these ossiculæ are articulated.

When commencing the examination of these bodies, at their origin from the vertebræ, Plate XVII. Fig. 16, a remarkable circumstance immediately arrested the attention: these articulated processes seemed to have passed out through the bodies of the thicker vertebræ. But that this had not been the case, appeared to me to be most reasonable to conclude, when I considered how much readier a passage, apparently, must have been found by them, between the vertebræ. Led by this consideration, I sought to discover the openings by which they had proceeded: but after examining various specimens with the utmost attention, hoping to detect some of these

bodies in their passage out of the column, I was at length satisfied that they had not passed in that manner; I, however, observed a considerable difference between the vertebræ; and, indeed, between the columns which they form, in those parts where these processes are seen coming off, and in those from which these processes do not appear to have been yet separated. A considerable groove is observable on that part of the flat side of the vertebræ, from which the processes have proceeded; whereas, in the latter, no such groove or depression appears.

From repeated examinations I have been, therefore, induced to suspect that these processes are not given off in either of the ways hitherto mentioned; but that, in succession, they are formed on, and detached from, the surfaces of the vertebræ, somewhat in the manner of epiphyses. I was first led to this suspicion by remarking on the sides of the vertebræ where these processes did not appear to have been given off, that a prominence was observable in that part in which, when they had been given off, a considerable depression appeared. This prominence, in some instances, also appeared to bear the figure of the ossiculæ of the processes, and even seemed to be surrounded by a line at which, perhaps, the separation would have taken place. This opinion, however, derived most support from the appearances yielded by the detached columns of other species, where not only the ossiculæ may be seen adhering, but even the foveolæ in which others have been fixed.

The ossiculæ of the vertebral processes, in whatever manner formed, appear to have been closely connected with each other, by such a species of articulation as was well calculated to admit the kind and degree of motion which these parts were intended to perform. The whole of the articulated process is composed of similarly formed bodies, which gradually diminish in their size, until they terminate in a small point. The animal seems to have possessed the power of coiling up very closely the terminating parts of these processes, so as to

have been able firmly to grasp even any small substance. A magnified view of one of these terminations is given, Plate XVII. Fig. 17.

Taking this circumstance in conjunction with that of the distance at which the greater part of these bodies are placed, from that cavity in which the mouth of the animal most probably existed, there seems to be sufficient reason for considering these parts as answering two purposes; being supplementary to the organ of attachment, as well as serving to assist in securing the prey of the animal.

The notion of their having been serviceable to the animal in promoting its attachment to adjoining bodies cannot fail to be formed in the minds of every one who observes the manner in which, like webbed feet, they are spread out in every direction, Plate XVII. Fig. 9. Besides, by this power of laying hold of different bodies with these tentacula, they were probably enabled to secure themselves in any particular spot, by clinging to a substance whose size and figure would admit of being thus grasped. That those also which are near to the superior part of the animal might also assist in securing its prey, and in conducting it to the fauces of the animal, is rendered evident by the specimen, Plate XVIII. Fig. 3, where these parts are very differently disposed from what is observable in the specimen last noticed. Here all the upper processes, instead of being widely extended, are closely laid together, extending upwards, parallel with the vertebral column, with their terminations collected round the brim of the pelvis, exactly as if aiding in preventing the escape of the prey.

Proceeding now to the superior part of the animal, I must again have recourse to analogy with the more perfect animals, as in the encrinites, to obtain names expressive of the parts to be here described. At this superior extremity, on the five sides of the vertebral column, are disposed those parts which, from their use, as I have already done with the corresponding part in the encrinites, I shall consider as the scapulæ of the animal, Plate XVII. Fig. 15, *a*. This

part is, in this species, formed of three trigonal pieces, the two lowermost of which are very thin, and are applied by one of their sides to the vertebræ; but the uppermost suddenly widens, so that the upper part of the surface, which is applied to the vertebral column, is exactly of the width of the vertebræ themselves.* On the summit of this body is a semilunar cavity, sloping outwards and downwards, in which a central foramen and a transverse ridge is observable. Between each of these scapulæ, on each of the angles of the vertebral column, a small body, *b*, is placed, which, from its assisting in attaching the scapula to the column, I consider, as I have done in the encrinites, as performing the office of a clavicle. The whole of these bones form the pelvis, in which the visceral part of the animal was, in all probability, deposited.

Immediately on the semilunar cavity of each scapula is disposed the piece which forms the first joint of the arm of the animal, Plate XVII. Fig. 15, *c;* and on this is placed the second piece, *d*, the lower side forming the surface with which it articulates with the preceding piece, and the two upper sides forming the surfaces with which the two first pieces of a new series of ossiculæ are articulated. At Fig. 13 is represented one of these ossiculæ of its natural size, with its surface of articulation: and beneath it is a representation of the same body slightly magnified.

The first ramification of the arms may be said to be completely dichotomous: but of the subsequent innumerable ramifications, a correct idea can only be obtained by a view of this part of the animal, or its representation, which has been endeavoured to be faithfully given, Plate XVII. Fig. 9, and Plate XVIII. Fig. 1. Another view of these parts is given, Plate XVIII. Fig. 2, where the ossiculæ are denoted by

* Were it not that it might have the appearance of aiming at too great a degree of nicety, and of labouring too much to make out the supposed analogy, I should have named the two lowermost of these bodies ribs, from the circumstance of their connexion with the vertebræ and the scapulæ, and for the sake of preserving a greater degree of uniformity in the nomenclature.

the same letters as in Plate XVII. Fig. 15. The specimen, Plate XVIII. Fig. 2, is well calculated to give a satisfactory notion of the form which the arms, fingers, and tentacula assume in a contracted state. In the middle of the lower part of this specimen, three of the scapulæ and the ramified arms may be seen; the fingers and tentacula closely filling every intermediate space.

In the specimen from Charmouth, Plate XVIII. Fig. 1, a very beautiful display of the arms, &c. of this animal is exhibited. In this specimen, neither the arms nor tentacula are more than half extended; a tolerable notion may, however, be obtained, from this figure, of the extensive power which this animal possessed of collecting its prey, and of directing it to its mouth.

On viewing the numerous arms with which this astonishing animal is gifted, you will, I trust, readily agree with me in the propriety of distinguishing it as the Briaræan Pentacrinite.

The finest specimen of this species which is, I believe, known, is in the possession of Charles James Harford, Esq. of Stapleton, near Bristol, a gentleman well known for the zeal and ability with which he has prosecuted his researches in this science. This fossil was found in a quarry at Keynsham, on the spot where Mr. Harford's extensive works are carried on. It was discovered eight feet below the surface, and beneath one solid bed of stone, two feet eight inches in thickness. By very great care in its removal, under the directions of Mr. Harford, a slab upwards of five feet in length, and four feet in width, entirely made up of the remains of this animal, was taken up, and deposited in that gentleman's valuable collection. Five or six of the vertebral columns of the pentacrinite traverse the length of the slab, the remaining part of the surface containing the detached as well as the connected pieces of the articulated vertebral processes, and of the arms and tentacula of this astonishing animal.

Having never seen, in any fossil, any body which could be consi-

dered as the lower extremity or organ of attachment of this species of pentacrinite, I anxiously examined Mr. Harford's fossil, with the hope of discovering its inferior extremity, but without success: even in this very large mass, nothing of this kind was discoverable.

Small slabs of the remains of this animal are found in various parts of England, particularly in Dorsetshire, where, in several parts of the cliff on the sea-shore, the remains of the animal are found attached to the rocks in a pyritified state, in very considerable quantities; but it very rarely happens that any pieces much larger than the two hands, and at the same time in tolerable preservation, can be separated from the rocks.

But the vertebræ of different pentacrinites are much more frequently found in a detached than in an united state. They are often found in this state in different parts of Gloucestershire, Leicestershire, Northamptonshire, Lincolnshire, Somersetshire, Warwickshire, Westmoreland, Cumberland, Yorkshire, and Lancashire. They are most commonly found in the bottom and sides of streamlets, and in the gravel of the rivers and sea, having been washed from the banks. Dr. Woodward observes that they are found plentifully in two banks at Whitton, in Lincolnshire, where the people call them *Castles* and *Apostles*. They are also frequently found in elevated situations; thus they very much abound on Breedon Hill, in Worcestershire, and on Lassington Hill, near Gloucester, where they have obtained the name of Lassington Stones. Both these and trochital vertebræ, from having been found in abundance in particular streams, have, from time immemorial, given particular names to such streamlets: thus a brook at Strickland Head, in Westmoreland, has hence obtained the name of Fairy-stone Brook.

A curious inquiry, perhaps worthy of the heraldic antiquary, is, how far the origin of the heraldic symbol, the mullet, has depended on the frequent discovery of these pentagonal vertebræ; since this sym-

bol is found very frequently in the coats of arms of the more ancient families in those districts in which these fossil bodies have been long known to abound. This circumstance has been particularly noticed by Dugdale, with respect to the family of the Shuckboroughs, for a knowledge of which I am indebted to that assiduous antiquary Mr. Thomas Fisher, to whom we are indebted for the publication, with several other interesting pieces, of a series of ancient paintings discovered in the Chapel of the Trinity, at Stratford-upon-Avon, in Warwickshire.

Shuckborough.

" This family," Dugdale observes, " do bear for their arms, *Sable, a Cheveron betwixt three mullets argent;* relating, as 'tis observable, to those little stones called *Astroites*, which are very like a mullet, and are frequently found in the plowed fields hereabouts."*

The calcareous masses of the remains of this animal will, in general, bear a very good polish, and then present a very pleasing appearance, from the delicate variegation of the marble by the slight traces of the animal remains: every part being so thickly beset with these

* The Antiquities of Warwickshire illustrated, P. 219.

remains, as not to leave the least appearance of any intervening matter. A specimen of this marble, in which the sections of the vertebral column are observable, is represented Plate XVI. Fig. 15.

In the year 1724, Dr. Eberhard Frederic Hiemer, of Wirtemberg, published a letter to Dr. Scheuchzer, describing a pentacrinite materially differing from any which has since been described.* The remains of this animal were found on a schistose slab, which was taken out of the quarries of Ombden, in the Duchy of Wirtemberg, and which was about four feet in length, and rather more than three feet in width. The whole of this slab appears to have been covered with the remains of the animal; several of its arms traversing the whole length of the stone, which was also exquisitely ornamented by the extremely minute, but perfectly distinct branches. The arms or larger branches were formed of pentagonal vertebræ, and crossed each other in different directions, appearing to have united and inosculated with each other at all these points of contact. The terminations of these arms are described as being a congeries of the most minute and slender branches, giving exactly the resemblance of a flower.

The distinguishing characteristic of the pentacrinite of Hiemer seems to be the union of the several vertebral columns, or of the arms or branches, at those points where they happened to have crossed each other, no such circumstance being observable in any of the other species of this animal.

The fossil here described was afterwards purchased of Mr. Hiemer, by Mr. Keysler, who presented it to M. de Hugo, in whose cabinet it was deposited. The size of this specimen, and the distinctness of the fossil remains which were displayed on its surface, enabled its original possessor to give that accurate description and

* Caput Medusæ utpote novum diluvii universalis monumentum detectum in Agro Wirtemburgico et brevi dissertatiuncula Epistolari expositum, ab Eberhard. Frider. Hiemero ; S. S. Theol. Doctore. Stuttgard.

delineation of it which allows me to conclude that it must be quite a distinct species of encrinite from any which are figured in this work.

Until farther observations have been made, or more specimens have furnished us with additional information respecting this species, I shall propose that it be distinguished by a name, derived from the characteristic difference of its structure, and that it be therefore termed the Anastamosing Pentacrinite.

LETTER XXV.

REMAINS OF THE GLOUCESTERSHIRE, SOMERSETSHIRE, AND YORKSHIRE PENTACRINITES.

We have seen that the stratum of the Briaræan Pentacrinite, which is so abundant on the Dorsetshire coast, at the south-west extremity of this island, appears to have extended northward within a small distance of Bristol; Mr. Harford's specimen having been found at Keynsham, between Bath and Bristol. On the other side of Bristol, on the banks of the Severn, the remains of pentacrinites of other species are met with; the stratum which has been formed by the remains of different species of pentacrini appearing to have extended from Dorsetshire, and from where the Severn empties itself into the sea, to nearly the northern extremity of the island. This tract, which is of considerable width, comprises Gloucestershire, Northamptonshire, Warwickshire,

Staffordshire, Lancashire, Yorkshire, Westmoreland, and Cumberland.

The avowal which I have now to make cannot but appear extraordinary to you:—although I have examined several portions of the remains of this animal, from most of the counties which I have enumerated, I am unable to speak, from my own knowledge, of any other part of its skeleton, than merely its vertebral column, with its lateral appendices; and, consequently, am unable to speak of the characteristic differences of the animals whose remains are found thus widely scattered. A part of a vertebral column of this species of pentacrinus, found in the mill-stream of Samuel Holbrow, Esq. of Leonard Stanley, in Gloucestershire, is represented, Plate XVII. Figure 8. At the upper part of this column, the terminating vertebra is rather enlarged, and has on each of its sides a considerable depression, which, with that of the adjoining vertebra, forms a pit, evidently fitted for the reception of one of its vertebral appendices. One of these vertebral appendices, obtained from this same stream, is shewn, Plate XVII. Fig. 7.

In the Briaræan Pentacrinite it was seen that the vertebral appendices issued from every vertebra, and were as closely set as possible. In this species, on the contrary, they must have been very thinly disposed; since one series only of these lateral processes appears to have belonged to this fragment, which consists of twenty vertebræ.

That the pentacrini which existed in these parts differed materially from the recent pentacrinus, as well as from the Briaræan pentacrinite, is rendered almost certain by the fortunate discovery of the fossil Plate XIX. Fig. 3, the representation of which is taken from the Fifty-second volume of the Philosophical Transactions. This fossil is described, by Mr. Ellis, as the head of an encrinus, with the ramified arms drawn up together. It is said to be in the cabinet of Mr. Francombe, and to have been found at Pyrton-Passage, Gloucester-

shire, in which part of the country, the asteriæ are found in very considerable quantities.

In the specimen, believed to be from Yorkshire, Plate XVII. Fig. 11, which is considerably bowed, the vertebræ have very deep angular recesses between the rays. This specimen is very interesting, since it teaches us a fact respecting these bodies which is not always pointed out by these fossils. The sides of the vertebræ on the inner sweep which they form are not above half the thickness which they possess on the outer part: this side of the vertebræ having been evidently compressed by the flexion of the column, during the life of the animal, and whilst capable of having their volume diminished by pressure. In the lower vertebra of this column, also, may be perceived the depressions in which the vertebral processes had been attached ; and above this are fifteen vertebræ, in none of which are any marks of similar attachments having existed.

The column from Yorkshire, Plate XVII. Fig. 6, is deserving of attention on account of the circumstances attendant on its distorted form. Following its flexion with a lens of moderate power, the circumstances on which its flexibility depended will be immediately perceived. As in the former specimen, so in this, in the inner line of each wave, the vertebræ are evidently thinner than on the outer. In the inner line, the crenated edges of the vertebræ are also seen, most closely pressed into each other; whilst, in the opposite line, they are separated nearly as far as can take place, without absolutely disengaging the crenulated edges of the articulating surfaces from each other, at this part.

This column is composed of three sets of vertebræ, of a larger, smaller, and medium size, thus arranged:—On each side of one of the medium size is disposed one of the smallest; beyond each of which is placed one of the largest size. This column is formed of thirty-one vertebræ, on the sixteenth of which, reckoning upwards, are the marks on each of its sides, where the vertebral processes have

adhered; and on the thirty-first, the uppermost, not only these marks are observable on three of its sides, but on one side the first ossicula of the articulated process is seen, and on the other surface five of these ossiculæ, two of which are still adherents to their original place of attachment, and the three which have slid off from the others are remaining close by their side.

On carefully examining and comparing together the ossiculæ of different articulated vertebral processes, I discovered an unexpected and important difference between those of the Gloucestershire pentacrinite and those which I conjecture to have belonged to the Yorkshire pentacrinite. This difference exists in their articulating surfaces; besides which, a difference is also observable between their respective forms. The ossiculæ of the Gloucestershire fossil are pentagonal, and in each articulating surface, a perfect stellated figure exists, differing only in its size from the star which appears on the vertebræ themselves. But in the Yorkshire fossils, the ossiculæ are rather of an oval form, similar to those of the Briaræan pentacrinite, and their articulating surfaces are formed on the side by four small depressions, and on the opposite side, by four corresponding eminences. These differences in the forms of the ossiculæ, and in their articulating surfaces are, doubtlessly, sufficient to separate these pentacrinites decidedly in two species.

The characteristic differences which will serve to distinguish from each other the Briaræan, the Gloucestershire, and the Yorkshire pentacrinites appear to be these. The Briaræan has its vertebral processes given off from every vertebræ, whilst, in the Gloucestershire and Yorkshire fossil, they are given off from distant vertebræ. In the Gloucestershire pentacrinite, the ossiculæ are pentagonal, and their articulating surfaces are radiated and crenulated like the vertebræ themselves; whilst the ossiculæ in the vertebral processes of the Yorkshire, as in the Briaræan pentacrinite, are of an oval or round form,

and their articulating surfaces are formed by corresponding slight eminences and depressions.

What other differences exist between these pentacrinites can, however, be only determined by more successful observations and more illustrative specimens than I can adduce, but which may be confidently expected from such admirers of fossils as reside near the places where these several species are found, and are disposed to make the necessary inquiries.

The observations of Mr. Lister on the vertebral processes of the pentacrinite, whose remains are found in the wolds of Yorkshire, are so illustrative of the history of these animal remains, as to render it probable that their admission in this place will be found advantageous. This gentleman remarks that

"There may be observed, in the deep-jointed pieces, just under the top joint above described, the vestigia of certain wyers rather than branches ; and sometimes two, three, or more joints of the wyers yet adhering. These wyers are ever five in number, viz. one in the middle or hollow part betwixt angle and angle. Again, in their jointed pieces, there are ever five of these wyers, or a set of them inserted into every conjugation of joints, so that it were some representation of the thing, to imagine the stalk of *Asperula* or *Equisetum*. Also, I have seen, but that very rarely, (not in one piece among five hundred,) a set of wyers in the middle of a deep jointed piece. One jointed piece I have by me, where a wyer of twenty joints and upwards (and how much longer they may be I know not) lies double within the hollow side, and by that accident was preserved in its natural place. It is no wonder," he observes, "that these wyers are knocked off, and but very rarely found adhering to the stones they belong to, being very small and slender, of a round figure, and smooth jointed, being set together *per harmoniam*, and not indebted suture. Nothing that I can think of is so like these wyers as the auturnæ of

lobsters. Lastly, some of these wyers are knotted, and others of them fairly subdivided or branched."*

Besides the several species of these animals, which have been spoken of in the foregoing pages, some others have also been described, which differ sufficiently from these to allow of their being considered as different species.

Mons. Davila has given a plate, representing a dark schist from the Duchy of Wirtemberg, on which appears a group of articulated tentacula, adhering to a calyx-formed basis.† This, in Mr. Walch's opinion, is one of the terminations of a pentacrinite, discovered by Gmelin.‡ This, however, does not differ in the least from the remains of these animals, which are constantly observed in the slabs from Dorsetshire. In the same work a specimen is represented, which is a piece of the yellow fissile stone from Pappenheim, bearing on its surface the remains of some animal, in many respects analagous with the pentacrinites. Ten arms, rather thinly beset with jointed tentacula, are discoverable; but no traces are seen of the trunk of the animal, nor do the parts, which are here preserved, bear a resemblance to any species of this animal which has been hitherto noticed. This specimen belonged to Professor D'Annone.§ A specimen of part of a vertebral column, formed of four sides, has been represented, Plate XIII. Fig. 59, similar to what has also been remarked by Rosinus. Mons. Schultz describes one of these animals as having a quadrangular base and eight rays.|| Mons. Guettard also describes one of these animals, the primary rays of which are four, and dividing repeatedly dichotomous, terminate in numerous small branches.¶

* Philosophical Transactions, Vol. IX. P. 276.

† Catalogue Systematique & Raisonné, Tome III. Tab. I.

‡ Monumens des Catastrophes, Tome I. Tab. XI. 6.

§ Monumens des Catastrophes, &c. Tome II. Parte 2de. P. 93. Tab. LI.

|| Betrachtung der verschinten See-sterne, § 19. P. 22.

¶ Memoires de l'Academie Royales des Sciences, 1755.

LETTER XXVI.

OPINIONS AND DISCOVERIES RESPECTING THE LIVING ANALOGUES OF THE PENTACRINITES.

THOSE who admitted the presence of animal life in the recent analogue of the pentacrinite, divided themselves into the supporters of two opinions. The one considered the whole of the encrinus, or pentacrinus, as belonging to a single individual animal, and place the mouth in the centre of the base of the pelvis, supposing the rays which are disposed round the pelvis to be so many arms which are used by the animal to convey its food to its mouth, and the projecting parts proceeding from the little cavities in the vertebræ as the instruments of motion. The others consider this body as a mass of as many separate polypes as there are articulations. The learned Hofer adopted the latter opinion, in his *Tentamen de Polyperitis*.* He represents the formation of such an assemblage of polypes, to which, when it has become a subject of the fossil kingdom, we give the name of Encrinite, to take place in the following manner. When one of these polypes, clothed with its testaceous covering, happens to be torn and separated from those to which it was united, the waves drive it from one side to another, until it happens to fix itself by its arms to

* Act. Helvet. Tome IV. P. 182.

some solid body. Then, by degrees, it changes its form, so that from a simple trochite with a cylindrical, smooth, and uniform surface, it becomes a tuberculous entrochite, and forms that part which is called the base of the encrinite, *basis radiorum encrini*, destined to become, as may be said, the stock of a numerous family: he forms five small polypes, which fix themselves in the five grooves on its surface. These five young polypes form others, and hence proceed the five branches form the base; the number of these doubling by the new polypes which push out from these; and thus forming a body with ten, and indeed at the end, with twenty rays, since the number of these polypes are doubled a second time. At the sides of those rays, small ossiculæ also attach themselves, with which are formed the fingers, and in this manner that which may be called the summit of the encrinus is completed. It now wants only that part which we name the stem of the encrinite; this he conceives to have formed by the successive apposition of new polypes, the first of which attaches itself to the inferior part of the base, and the succeeding ones apply themselves in the same manner to each other.

Such is the opinion of Mons. Hofer. He, however, modestly offers it merely as a conjecture, subject to numerous difficulties, and thus we find it. This theory is composed of too many gratuitous suppositions. The structure of the pelvis, &c. does not seem to be at all reconcilable with the idea of the arbitrary assemblage and apposition of polypes. How is it possible that a trochite can transplant itself into the various parts composing the pelvis, none of which parts bear any resemblance to a trochite? and, nevertheless, according to this theory, all these parts ought to have been formed by polypes of the same species. How is it possible that one polype should form a body of a triangular shape; another, of the same species, a hemispherical body; and another again, a body of a cylindrical form? If every joint has its own separate polype, how happens it that, upon contracting at its death, the whole body preserves so much regularity in its form? If

the stalk is the work of new polypes which have chanced to place themselves there, how happens it that sometimes they form cylindrical bodies, and at other times, at certain distances, spherical bodies? If the stem is constructed by a string of polypes, which fix themselves beneath the base, how happens it, that only one, and not several rows of polypes thus attach themselves? and how does the first of these polypes find, so exactly, the centre of the base? These are questions which, as Mr. Walch justly observes, the supporters of this opinion would have much difficulty in resolving. It does not appear to be necessary to make any farther remarks on this opinion: that the encrinal compages is the labour and habitation of a single animal, is sufficiently obvious.

Respecting the animal, which should be considered as the recent analogue of these fossils, numerous fruitless conjectures have been formed, the more important of which it seems to be proper briefly to notice, as nearly as I shall be able, in the order in which they have been proposed.

The separation of the rays of the *Asterias Caput Medusæ*, Linn. into numerous minute articulated branches, led several naturalists, among whom may be mentioned Rosinus, Gesner, Bourguet, and Bertrand, to believe that the encrinites and pentacrinites were fossil remains of some animal of a nearly correspondent species. Lhwydd very strongly maintained this opinion in a Dissertation *(Prelæctio de Stellis Marinis)* annexed to Linck's elegant work, *De Stellis Marinis;* but Linck himself, having pursued the inquiry with requisite care and zeal, informed Mr. Lesser that he could not discover any sea-star which could be considered as being analogous with the encrinite described by Rosinus and Harenberg.

The ascertaining of the important differences existing between these fossil bodies and the Caput Medusæ; particularly in the mode in which their ramifications are formed, and in the absence of the trochital or asterial column in the Stellæ Marinæ, left these fossils

without any recent animal with which they could be considered as analogous.

In the year 1753, Mr. Mylius, in a letter to Haller, described a new kind of zoophyte caught in the North Sea, which somewhat resembled the encrinus. Mr. Ellis, also, about the same time, obtained another of these animals caught in the same sea.* Some slight agreement having been observed between the general form of this animal and that of the lily encrinite, several naturalists were inclined to suppose that the real analogue of the fossil animal was discovered. A very slight degree of attention, however, was necessary to discover that no real similitude existed between the two animals. It will be sufficient to observe here that neither the column nor the rays of the recent animal are, like those of the encrinus, articulated ; nor do its rays proceed from a regularly formed base, as do those of the fossil animal. Indeed, to the present day, no animal has been discovered which can be said to bear the least analogy with any of the different species of encrinites.

Various conjectures were also formed, and numerous researches were made, with the hope of discovering the recent analogue of the pentacrinite, but without any success, until Madame de Boisjourdaine, of Paris, was presented, by a friend from Martinique, with a fragment of a new and curious zoophyte, which he had received from a captain of a ship, who was unable to say in what sea it had been found. At the death of Mad. Boisjourdaine, this curious specimen came into the possession of Mons. Davila. But it is to Mons. Guettard that we are indebted for having first manifested the relationship between it and the pentacrinites.

This zoophyte appears to be undoubtedly a species of pentacrinus, in its recent state. Like the fossil animal, it is described as possessing an articulated vertebral column, on which is supported a cluster of

* The Natural History of Coralline, Plate XXXVII.

articulated and ramifying arms. The vertebral column, which is pentagonal, is from seventeen to eighteen inches in length, and might have been much longer, as it has evidently been broken off, at its lower part. It is formed of flat pentagonal vertebræ, pierced in their centre. Every vertebra possesses a stelliform surface on each side, derived from the arrangement of the depressions, and the apophysal eminences: the eminences and depressions of each opposed surface being mutually adapted to each other, so as to produce an exactly fitting articulation. Through the central foramen, a membranous, nervous, or filamentous substance passes, which, from its introduction into all the minute lateral foramina of the vertebræ, seems to contribute much to the retaining the parts of the vertebral column in their proper situation: and between each vertebra, a soft cartilaginous body is interposed, by which the necessary motions of the trunk must have been greatly facilitated. At regular distances, diminishing as they approach the superior part, articulated processes are given out from each of the five sides of the vertebral column. The arms of this animal, which are five in number, proceed from the sides of the superior vertebræ, and form, by their divisions and repeated subdivisions, innumerable ramifications or fingers, the sides of which are beset with articulated tentacula.*

With respect to the substance of this body, it appears to hold a middle place between bone and cartilage, approaching to that of which the shells of echini are formed; and even in this its recent state, it bears some resemblance to a spathose substance from its lamellated texture, and the brightness of its fracture. To this specimen the name of *Palma Marina* had been given. A slight sketch of the remains of this recent animal is given Plate XIX. Fig. 1.

Mr. Ellis also gave the following account of what he terms a recent encrinus, or star-fish, with a jointed stem, found on the coast of Barbadoes.

* Memoires de l'Academie des Sciences de l'An. 1755.

" *Encrinus, capite stellato ramoso dichotomo, stipite pentagono, equisetiformi.*

" The stem and head of this animal, in its present state, measures about fourteen inches, the stem is about thirteen inches in height, and about the third of an inch in diameter, lessening a little towards the top: it is formed of pentagonous joints, or vertebræ, placed regularly over one another, which are of a testaceous substance, and united by very thin cartilages, as appears by examining minutely the base of the lowest vertebra, where it is fastened to the starry indentures of the joint: this makes the vertebræ capable of bending at the will of the animal, in any direction.*

" If we examine the five furrows or channels along the stem, we shall discover a small hole between every vertebra; and in the centre of the base of the lowest, we shall find a small hole there, which probably communicates through the middle of all the vertebræ, to the cavity in the centre of the head.

" Along this stem, at different distances, from an inch and a quarter to a quarter of an inch in length, we observe many series of five cylindrical jointed arms, each series is of equal length, and placed in a wheel or whirl-shaped form, like the equisetum or horse-tail plants. Each arm is inserted in one of the five cavities of a vertebra, and each joint into one another, that the upper end of one joint inclines over the lower end of the next to it, which it appears, at the same time, to inclose with a small margin. These joints are generally about one-twelfth of an inch in length, and the same in diameter, and have a

* There can be little reason to doubt that the membranous substance, mentioned Page 166, as separated from the surface of a trochites, by the action of the muriatic acid, was originally of a similar nature, with the cartilage which is here described as interposed between the vertebræ of the pentacrinite.

small hole communicating with the starry centre of the vertebræ, and running through their centre to the hooked joint at the extremity of these arms.

"On the under or inner side of these joints, their surface is rendered uneven by minute tubercles, by means of which, and of the hook, which the last joint forms, the animal can take a more secure hold of whatever he seizes.

"But as the stem of this animal appears to be broken off at the bottom, we must remain in doubt whether it moves about in the sea, or is fixed to rocks and shells by a base, like corals, sponges, and keratophytons.

"We now come to what is called the head, perhaps the body, of this animal; for in the centre of this dry specimen, there still remains a cup of a crustaceous substance, and of an oval form, about an inch in length, and three quarters of an inch over, and a quarter of an inch deep; in the centre of this is a small hole, which, apparently, communicates with the internal part of the vertebræ of the stem: in this cup or cavity, it is probable, were the intestines and stomach of the animal, as in the asterias, called Caput Medusæ. This cup is supported by the bases of six dichotomous testaceous arms or branches, (perhaps five is the natural number, for one seems irregularly placed). These lower parts or bases of the branching arms consist of three joints each, and surround the cup, to which they seem united; each of these divide into two other jointed branches, that are round or convex on their under side, but flattish on the upper, with a deep groove running along the middle, which is furnished with two rows of suckers, like the sepiæ or asteriæ. From the upper edges of each alternate joint of these branches arise two rows of small jointed claws, like fingers; these two opposite rows bend in towards each other: each small branch or finger is about half an inch long and one-twentieth of an inch broad; the size of these joints diminish a little, till you come to the last joint, which ends in a point. Each of these

joints is pointed at top, and being concave, embraces the lower convex part of the next above it; these are likewise furnished on their concave side with two rows of suckers, clasping together; they secure their prey with these opposite claws or fingers."*

The specimen here described was in the museum of the late Dr. Hunter, which has been lately transferred to the University of Glasgow. Another specimen, apparently of the same species, was also in the museum of John Hunter, Esq. and is now in the possession of the Royal College of Surgeons, of London.

By the discovery of these valuable remains, it has been ascertained that recent animals exist which are at least of the same genus with the pentacrinites whose remains have so long engaged the attention of the curious. It does not, however, appear certain, from the opportunities which have hitherto occured of making the necessary comparison, that either the specimen of the recent animal of Mad. Boisjourdaine, or those which we have in this country, can be considered as being of the same species with those with whose fossil remains we are acquainted. The difference between the Briaræan pentacrinite and the recent pentacrinus is very evident, not only in the formation of the pelvis, but in the much greater number of the vertebral processes and tentacula in the former than in the latter. The fossil remains of the pentacrinite, which chiefly abound in Gloucestershire, Warwickshire, and Yorkshire, are in too imperfect and unconnected a state to admit of any comparison with the recent animal, which can lead to any important decision.

But it indeed appears, from the superior part of a pentacrinite, slightly sketched, Plate XIX. Fig. 3, and copied from the fifty-second volume of the Philosophical Transactions, that the pentacrinite of Gloucestershire must have materially differed from the recent pentacrinus, the latter not appearing to be capable of being con-

* Philosophical Transactions, Vol. LII. Part 1. P. 357.

tracted into a body of a similar form. The fossil referred to is described "as the ramified arms of the head of an encrinus, closed up together. From the cabinet of Mr. Francombe; found at Pyrton Passage, Gloucestershire."

In the several species of encrinites, whose superior parts have been sufficiently perfect to allow of their examination, it has appeared that the ramifications or fingers were given off in so regular and uniform a manner as to render them capable of being closed exactly together; the projecting parts all fitting into corresponding depressions on the opposite parts. In the pentacrinites, on the contrary, the branches not appearing to be given off with such regularity, and being at the same time extended to a considerable length, and amply supplied with lateral processes or tentacula, which are also very long, there does not appear to be reason for supposing that they were capable of being contracted into a compact assemblage, bearing a regular form, similar to those of the different species of encrinites.

But in this fossil, which is evidently a pentacrinite, since a pentagonal asteria is depicted as still adherent to its base, ten arms proceed from its pentagonal base, much in the same manner as in the lily and cap encrinite. These arms also bifurcate somewhat in the same manner as is observable in the arms of those fossils; the divisions, however, more closely resembling the divisions which take place in the arms of the cap encrinite; a first division taking place at about the third articulation, and the fingers which are thus formed being repeatedly subdivided in a dichotomous manner. The whole of the arms and fingers, although so repeatedly separated, as is shewn in the figure, evidently possessed the power of so contracting themselves, as thereby to acquire a regular and determined form. We are, I think, fully warranted in considering this fossil as the superior termination of the Gloucestershire pentacrinite.

LETTER XXVII.

ATTEMPT TO ASCERTAIN THE NUMBER OF SPECIES OF THESE ANIMALS.

It is my intention to devote the present letter to the endeavour to ascertain, as nearly as I may be able, the real number of species, under which such of these extraordinary animals, whose remains we are at present acquainted with, may be arranged. With this view, I shall place before you a recapitulatory sketch of the several species which have been described in these pages, and shall add to these such species as have been mentioned by some authors; but the specimens of which are so rare as not to have come under the observation of but very few others.

The several species which have been particularly noticed in this volume are,—

I. The Lily Encrinite, described by Walch as the encrinite with a pentagonal base, and ten bifurcated rays; being the *Stone-Lily* of Germany, so accurately examined by Rosinus, and described in Letter XVII. of the present volume.

II. The Cap Encrinite of Derbyshire, and perhaps of Yorkshire; see Letter XIX.

III. The Turban Encrinite of Shropshire; see Letter XIX. Some very indecisive remarks on some remains of this species, from the Isle of Gothland, I have shewn, have been made in Knorr's celebrated work.

IV. The Pear Encrinite, of Bradford; see Letter X.

Some imperfect remains of this fossil appear to have been also found in Germany, and are noticed in the work just mentioned.

V. The Nave Encrinite, of Yorkshire and Gloucestershire; see Letter XXI. Dr. Capeller has described several specimens which appear to be of this species, and which he had obtained from the Isle of Gothland.

VI. The Plumose Encrinite, of Staffordshire, in the possession Mr. Donovan, and described in Letter XXI.

VII. The Tortoise Encrinite, of the English chalk-pits. Letter XXII.

VIII. The Straight Encrinite . . . . ———

IX. The Bottle Encrinite . . . . ———

X. The Stag's-Horn Encrinite . . . . ———

XI. The Clove Encrinite . . . . ———

This fossil is also frequently found in the mountains of Switzerland.

XII. The Digitated Encrinite.

Although the great difference observable between the specimens, represented Plate XVI. Fig. 9 and Fig. 16, is sufficient to warrant the supposition that there must be two distinct species possessing these digitated processes, I have not ventured to assume this as a fact; choosing rather to wait for the discovery of specimens which may prove more illustrative of this particular circumstance.

XIII. The Oval Encrinite. Both this fossil and the foregoing are described in Letter XXII.

XIV. The Briaræan Pentacrinite, of Dorsetshire and Somersetshire, described in Letter XXIV.

XV. The Anastamosing Pentacrinite, described by Hiemer.

XVI. The Fig Pentacrinite, of Gloucestershire, described in the Philosophical Transactions; see Letter XXV.

XVII. The —— Pentacrinite, of Yorkshire.

To these I shall add the following fossils, which have been described by other authors, but whose rarity has hitherto prevented their nature from being duly investigated.

XVIII. The Encrinites with four rays. This fossil is spoken of by Mons. Guettard, in the Memoirs of the Royal Academy of Sciences, for the year 1755.* He remarks that in this species of encrinite each of the principal rays is divided into two, which are again divided into two others, from which proceed a considerable number of small branches. The opinion of Mr. Walch, that this species might, perhaps, be referable to the pentacrinites, derives support from the existence of quadrilateral asteriæ, which would, of course, have belonged to a pentacrinite possessing four arms.

XIX. The Encrinite with five or six rays. Such a fossil is described by M. Harenberg, in his treatise *De Lilio Lapideo;* but it does not appear to have been seen by any other author.

XX. The Encrinite with eight rays and a square base. This species is mentioned by M. Schulz, in his description of the petrified *stellæ marinæ.* No other author appears to have described this fossil.

XXI. The Encrinite with twelve rays and a hexagonal base. This encrinite is figured and described by Rosinus, in Plate I. and page 34, of his excellent treatise *de Lithozòis.* Rosinus describes the trochitæ of this species as being characterized by concave articulating surfaces, bearing the figure of a pentapetalous flower, with a similar but much smaller floweret in the centre.

* Recueil de Monumens des Catastrophes, &c. Tom. II. Sect. II. P. 89.

An Encrinite with twenty rays is mentioned by M. Schulz: but Mr. Walch, although unwilling to doubt the fidelity of the description given by M. Schulz, remarks that it is possible that the arms of the common encrinus, or stone-lily, might have been reckoned after their division, and thus the real number might have been doubled. The probability of this will be allowed, when it is considered that the imperfect state of a specimen often occasions very deceptive appearances; and this probability will be still more readily admitted, on considering the formation of the cap encrinite, Plate XV. Fig. 9, in which, from the irregularity and the greater frequency of the subdivision of its limbs, the animal might be supposed, by an inspection of its superior part only, to have possessed double the number of arms which it really does.

The appearances presented by the polished slab of marble, containing the pentacrinite of M. Gmelin, hardly at all differ from those which present themselves in the pentacrinital marble of Dorsetshire.

Of the supposed pentacrinite, discovered by M. D'Annone in a piece of the calcareous stone of Pappenheim, little positive can be said. Since only the terminating branches and no part of the trunk of this animal was discovered, it is impossible to determine whether it should be considered as an encrinite, pentacrinite, or fossil stella marina; but from the very close resemblance which it bears to the Stella *δεκακνημος barbata seu fimbriata Barrellieri*, figured by Linck, Tab. XXXVII. Fig. 64, as well as to others of the *Stellæ Crinitæ*, there appears to be very strong reason for supposing this fossil to be the remains of some of these species of Stellæ.

The Encrinite described by Dr. Capeller, and mentioned in

Letter XXI. which agrees in every respect with the nave encrinite, excepting that the plates composing its base, instead of being smooth, are strongly marked by lines forming rose-like figures, is in too imperfect a state to allow of its being determined whether it should be considered as a different species from, or merely a variety of, the nave encrinite.

An Encrinite is described by M. Guettard, as bearing several bodies or flowers on the same stalk. M. Guettard observes that several encrinites of this description were found in Franche Compté by M. Loreau; but Mr. Walch suspects, with reason, that these were rather pentacrinites of the same species with the one described by M. Hiemer, and already noticed. This I therefore consider as not deserving to be considered as of a distinct species.

The pentacrinite described by Mons. Davila, as the petrified marine palm, and as exactly agreeing with the recent pentacrinite of Madame Boisjourdaine, is thought, by Mr. Walch, of the same species with the preceding.

From the foregoing enumeration it will appear that, without assuming the American fossil, Plate XIII. Fig. 36 and 37, which, however, bears strong marks of an affinity with the nave encrinite, and the fossil represented Fig. 80 of the same plate, to be encrinites; and without reckoning, as probability would almost authorize, that the trochitæ, Plate XIII. Fig. 7, 18, 27, 33, and 69, belong to separate species of these animals, we are yet able to reckon upon the existence of twenty-one decidedly distinct species.

It cannot but be highly gratifying to the British naturalist to learn that, among her subterranean treasures, Britain can reckon fourteen of the species above enumerated, viz. 1, the cap encrinite; 2, the turban encrinite; 3, the pear encrinite; 4, the nave encrinite; 5,

the plumose encrinite; 6, the tortoise encrinite; 7, the straight encrinite; 8, the bottle encrinite; 9, the stag's-horn encrinite; 10, the clove encrinite; 11, the digitated encrinite; 12, the briaræan pentacrinite; 13, the fig pentacrinite; 14, the ——— pentacrinite, of Yorkshire.

Besides the species here particularized, numerous fossil fragments have been found in this country, which bear evident marks of having belonged to species of these animals very different from any which are at present known: a circumstance which cannot fail to add to the zeal and industry of those who have justly appreciated the aid which these inquiries may yield in the establishment of geological principles.

LETTER XXVIII.

GENERAL REMARKS ON THE FOSSILS ALREADY DESCRIBED.

In the series of letters, composing the former volume, various facts were adduced, in proof of the solid part of this globe having, at some very distant period, been covered by water. An unexpected circumstance was at the same time noticed;—hardly any agreement could be found between the fossil vegetable remains and those vegetables with which the earth is at present clothed; and, in the present volume, an equal want of agreement has been observed between the fossil remains and the actually existing animals of the order of zoophytes.

That, in the stupendous changes which this planet has undergone, several species of beings, endued with vegetable or animal life, should have become extinct, is by no means inconsistent with the conclusions to which an unbiassed consideration of those grand events would lead. The discoveries, therefore, in the vestiges of a former world, of the remains of innumerable vegetables and animals, such as would constitute a prodigious number of species, and such as, according to the strict laws of arrangement, might be even disposed in new and distinct genera, although quite unexpected, is not in contradiction to what, on reflection, we should have admitted might, from the influence of particular circumstances, have occurred. But a fact has been

established in the former and in the present volume, to the expectation of which no chain of reasoning could have led. Of the numerous vegetables and animals with which the earth is at present furnished, the mineralized remains of very few species indeed can be found: of man himself, the mineral world presents not a single trace—an explanation of which I in vain attempted in the preceding volume.

Whilst instancing this wonderful want of accordance of the mineralized organic remains of a former period with those beings which are known now to exist, I shall here confine myself to such facts only as have been noticed whilst examining the fossil bodies which have engaged our attention in the present volume.

The examination of fossil corals was commenced, as may be seen, with the expectation of being able to preserve somewhat of a parallelism between the corals of this and those of the former world. But it soon became necessary to abandon this attempt, it appearing that, of the fossil corals, which, it may be said, have been only fortuitously discovered, many more species have existed than are known of even the recent corals, which, from their beauty and various other circumstances, have been so long and so assiduously collected. This abandonment was further authorized by its also appearing, on comparison, that scarcely any specific agreement could be established between the recent and the fossil corals.

With respect to the degree of accordance of the fossil with the recent alcyonia, sponges, and other soft and, consequently, easily altered zoophytes, I considered myself as not authorized to speak with confidence; since, it being probable that, from these bodies never having been the object of very general attention in a recent state, many may be yet withheld from our knowledge, which might, when found, considerably reduce the number of those fossil species which we are obliged, at present, to consider as without any recent analogues.

With respect to those zoophytes, with the examination of which the latter part of this volume has been engaged, it must be acknowledged

that they seem to point out most decidedly a considerable want of agreement between the inhabitants of the former and of the present world. It appears that of these zoophytes, which, perhaps, should be arranged under two genera, encrinus and pentacrinus, upwards of twenty species are known in a mineralized state; but that, incalculably numerous as these animals must have been, not a single fragment of any individual, of any of the numerous species belonging to the genus encrinus has ever yet been seen in a recent state. Two or three fragments of pentacrini have indeed been discovered, but whether exactly agreeing with any of the fossil species I have not been able to ascertain.

No stronger proof need be required of the sea having long covered this globe than the various mineralized remains of zoophytes which have been found in different parts of the world, imbedded at considerable depths and at very great elevations, in some of the loftiest limestone mountains. But it may be argued that although the marine origin of these remains be admitted, and although they are found thus imbedded, still it is not yet proved that the sea has rested on the parts where these fossil remains have been found; since they might have been brought there by floods from distant parts. But that these animals dwelt, and perished on the identical spots where they are now found, in a mineralized state, may be fairly and, I trust, unquestionably, inferred from the circumstances of the congregation of similar animals, and of their bearing but few marks of external violence; since, had they been thus transported from distant regions, individuals of similar species would have been separated, and scarcely any individual, except of very strong fabric, would have been found that had not suffered material injury.

Reverting to what has been remarked of corals, that it is not very frequent that the superior external face of the coral is found in our fossil specimens, it might be thence remarked that this was most probably the result of attrition, during the conveyance by the waves from

one spot to the other. But when it is considered what prodigious masses are often formed by one species of coral, as in the recent coral reefs in the South Sea, it will naturally occur to the mind of every one that, in cabinet specimens of fossils, which are the small fragments of such masses mineralized, by far the greater number of specimens may be expected to be found not possessing this, the most characteristic surface of the fossil.

Instances of the vast quantities in which these corals were accumulated may be found in various marbles of which they form the basis, and which are in masses sufficiently large to allow of being cut into slabs of very considerable size, and to shew that they could not have been brought by the waves to the places where they now are found. Corals, in a mineralized state, yield also ample testimony of similar species having congregated together in particular places. The Swedish Islands of Gothland and Oeland, as well as many other parts of Sweden; Worcestershire, Shropshire, Perthshire, Fifeshire, and many other parts of Great Britain, possess considerable numbers of the simple turbinated madrepore.* In Wales, are to be found considerable masses of the remains of the curious madrepore, distinguished, by Lhwydd, as *Lithostrotion, sive Basaltes minimus striatus et stellatus.* In Westmoreland, Cumberland, the bishopric of Durham, and several other parts of Great Britain, as well as of the Continent, are considerable accumulations of particular species of the aggregated and compound madrepores.

The softer zoophytes, such as the sponges, alcyonia, &c. evince still stronger marks of their not having been conveyed by torrents to their present residences. Many of these are of such a structure as certainly could not have borne such a conveyance with so little injury as is discoverable in the several specimens, which have been examined in the

* I lately received, from some unknown friend, two of these fossils, which were found about thirty feet deep, in a mass of calcareous rock, at Lord Elgin's lime-works, on the banks of the Firth of Forth, in Fifeshire.

preceding pages. But the congregation of so many of these bodies in particular districts, as has been already noticed, particularly in France, in Switzerland, and in this island, still more strongly proves these to have been the identical parts where they lived.

But should any doubt remain of the fossil zoophytes having inhabited the sea, in the identical places where they are now found, penetrated with and entombed in stone, those doubts must yield to the still more convincing circumstances which attend the fossil remains of encrini and pentacrini. The marine origin of these animals, we have seen, has been determined by the discovery of the recent remains of two or three pentacrini in the Atlantic Ocean: and that the fossil species must have had their existence where they are now found is plainly evinced, not only by the vast accumulations of distinct species in particular districts, but by several instances occurring, particularly with the lily encrinite, where, notwithstanding the extreme delicacy of their construction, even the more minute and more easily separable parts have been repeatedly found, in their mineralized state, preserved in almost their natural connection.

In concluding the present volume, it seems necessary to remark that the circumstances observed whilst examining the several fossils hitherto noticed, have appeared to be sufficient to warrant the following conclusions.

1st. That the water has rested for a considerable period over the general surface of the earth.

2nd. That the mineralized zoophytes, found imbedded in different parts of the earth, and even in mountains of considerable height, have lived and died on those identical spots which, in the former world, constituted parts of the bottom of the ocean.

3rd. That, in a previous state of this planet, many species of organized beings existed which are not known to us in a recent

state; their having existed being proved only by the discovery of their fossil remains.

4th. That the traces of very few of those species which now exist can be discovered in the wreck of a former world.

5th. That, even in rocks of the newest formation, and in alluvial strata, which are comparatively of but modern deposition, the remains of extinct animals are as frequently to be found as in what are termed Transition Rocks, (those which are supposed to contain the first traces of organic remains).

6th. That there appears to have been no line of separation between the creation of species now extinct and of those now existing; since not only the remains of extinct species, but, perhaps, of extinct genera, are found with the remains of species very similar to, if not exactly agreeing with, species known in a recent state.

7th. That many of the pebbles found in gravel-pits, on the shores of rivers, and on the sea-beach, do not appear to have been bowldered down to the form in which they are now found; but that, on the contrary, their present forms are precisely those which they at first derived from the silicious impregnation of different animals which existed in the former ocean.

8th. That, judging from the original delicacy of structure in these bodies, and from the little injury which they have sustained, it appears reasonable to suppose that this solidification was effected, in several instances, previous to the removal of the waters from their former bed.

LETTER XXIX.

OBSERVATIONS ON THE PROCESS OF PETRIFACTION.

I ATTEMPTED, in the preceding volume, to shew that the generally received opinion respecting the formation of petrifactions is erroneous; and endeavoured to support my conjectures by a particular examination of various vegetable fossils. It has been supposed that, in every instance of petrifaction, the lapideous is substituted for the vegetable or animal matter, as this is decomposed and removed. This removal and substitution has been also supposed to be so gradually performed, molecule by molecule, as to allow the earthy parts, whilst arranging themselves in the spaces left by the removal of the organized matter, so to mould themselves into those spaces as to take exactly the form of the organized part, and to imitate it precisely, in every trace. In this manner, the petrifaction, as it is termed, is supposed to have acquired the exact form and most of the characteristic appearances of the orginal body, without retaining any at all of its original particles. This mode of explaining the formation of petrifactions has been adopted by almost every chemist and mineralogist who has written on the subject; and has been particularly described by Kirwan, Walch, Daubenton, Fourcroy, and Haüy; the latter gentleman giving it as the explanation which is most generally admitted, although he acknowledges that it may not be free from difficulties.

Dissatisfied with this explanation, I suggested that the organized part was not removed, but that it remained in part, at least, and became the *substratum* of the fossil, on which was deposited the lapidifying matter. I endeavoured to shew that vegetable substances, in certain situations, were rendered bituminous; and were, in that state, capable of being thoroughly pervaded by water, and, of course, of being imbued with the saturated solution of any earth; and that, by the formation of minute crystallizations through the whole impregnated mass, a consolidated silicious or calcareous

substance would be formed, without disturbing the existing arrangement of those parts, on which the form and general appearance of the fossil would depend. To determine how far this opinion was correct, wood, petrified by flint, was subjected to simple distillation over a naked fire, when an oily sublimated film, possessing a strong empyreumatic smell, was obtained. It could not be expected, from the refractory nature of silica, that any thing more decisive could be obtained from any experiment on opaline wood; since no agent could, perhaps, be employed for the removal of the earth which would not, at the same time, entirely decompose the bituminous substratum.

But in calcareous fossil wood this objection did not exist, since by the employment of any dilute acid, the earth might be removed, and it might be clearly ascertained whether the presumed vegetable or bituminous matter was present or not. The experiment was made, and with complete success: the carbonate of lime was removed by diluted muriatic acid, and a dark brown, friable, but coherent mass remained, which bore every appearance of bituminous wood, and which, when brought into contact with the flame of a candle, directly burned with a small, bright, lambent flame, and yielded a strong bituminous odour.

From this experiment, I conceived that I was warranted in concluding that, with respect to vegetables, the process of petrifaction is not merely, as Mr. Kirwan supposes, the *substitution* of stony or metallic bodies, in the place of the organic substance which has been destroyed by putrefaction;* nor, as is taught by Fourcroy, that the petrifying matter is deposited as in a mould: the complete destruction of the vegetable matter and the disappearance of whatever constituted its elements taking place at the same time.† But that a part of the organic matter still remained, though somewhat changed; and that the process of petrifaction was the *impregnation* of this sub-

* Geological Essays, P. 137.

† Systeme des Connoissances Chimiques, Tome VIII. P. 255.

stance, and the filling up of the interstices with the lapidifying matter.

But it still remained to determine if a correspondent organic matter existed in animal fossils. To ascertain this point, therefore, the various kinds of animal fossils noticed in this volume were subjected to a chemical examination, by which the most satisfactory proofs were obtained of the existence of this animal matter, and even of its retaining, in several instances, very much of its original form.

This circumstance was beautifully illustrated by the examination of an entrochus of the lily encrinite, the particulars of which are mentioned page 166, and are illustrated by the engraving Plate XIII. Fig. 47. A similar examination of the fossil tubipore, Plate I. Fig. 1, was equally successful; the animal membrane belonging to the coral, from which the marble derived its origin, being rendered exceedingly evident. Indeed, in a subsequent examination of this marble, the success was far beyond expectation; the animal membrane was displayed, retaining the general external form with the original colour of the coral. The experiment was performed with equal success with several other substances; particularly with a piece of the Derbyshire entrochal marble, the animal membrane of which was rendered perfectly distinct.

Other experiments have already convinced me that the presence of organic matter in animal fossils, of almost every kind, is sufficiently frequent to authorize, in the fullest manner, the opinion which I have already advanced, respecting the principles on which the process of petrifaction is accomplished. In the vegetable fossils, it is true, that the organic matter appears to have undergone a particular change, having been previously brought to the state of bitumen; and I have strong reasons, the result of actual observation, for believing that, in the animal fossils, a correspondent change has been previously induced, and that the animal matter has suffered a conversion into adipocire.

PLATE I.

FIG. 1. A tubiporite, somewhat approaching to the *Tubipora Musica,* imbedded in a dark coloured limestone, from Derbyshire, P. 13.

2. A piece of marble, chiefly formed by a tubiporite of this species. This marble has a red tinge, apparently from the original colour of the coral.

3. The remains of a fragment of marble of the preceding kind. In consequence of having been exposed to the action of dilute muriatic acid, the lapideous part of the marble has been removed, the animal membrane of the coral, still retaining its colour, only remaining.

PLATE II.

FIG. 1. A tubiporite agreeing with the fossil tubipore of Linnæus, described as *Tubipora Strues*, forming a lightish brown marble.

2. Longitudinal section of the madreporean star.

3. One of the feet, or rather arms, of the madreporean insect, described by Donati, as employed in forming its habitation, the madrepore.

4. The whole animal; its head being in the centre, surrounded by its numerous arms, which may be considered as the instruments with which the animal forms the lamellæ of the madrepore.

*** The three last figures are copied from a plate in Ellis's Zoophytes, being there undescribed: no description of them having been found in the papers of Mr. Ellis.

PLATE III.

FIG. 1. A ramose tubiporite from Mendip Hills. The corallite, which is silicious, is imbedded in a dark lime-stone.

2. Is taken from the twenty-seventh plate of Mr. Ellis's Natural History of Zoophytes, and serves to shew the material difference which exists between the recent *Tubipora Musica* and the fossil tubipores, Plate I. Fig. 1.

3. A fragment of black and white marble, which derives its marking from the tubiporite, Fig. 1.

4. Chain coral *(Tubipora Catenulata)* in its matrix ; but sufficiently cleared to shew its form and structure.

5. A view, transversely, of the same tubiporite, imbedded in its matrix.

6. A transverse section of the same fossil, placed between the eye and the light.

PLATE IV.

Fig. 1. Turbinated madreporite, possessing somewhat of a pyramidal form: remains of its radicle being observable around its lower parts.

2. A fossil of the same species; but more of a discoidal form.

3. Another fossil of the same species; at the lower part of which, traces of the root-like projections are also observable. About the middle of the coral a cleft divides it through about half its diameter: the coral-forming insect having there partly finished his labours and began them a-new.

4. The stellated surface of a madreporite, bearing a very peculiar form.

5. A turbinated madreporite, somewhat resembling *Madrepora Cyathus.* Linn.

6. The shirt-button madreporite, *(Madrepora Porpita.)* Linn.

7. A turbinated madreporite, the external coat of which having been removed, the disposition of its perpendicular lamellæ is displayed.

8. A section of an elongated turbinated madreporite: displaying its transverse and longitudinal lamellæ.

9. A simple madreporite, bearing the form of a compressed cone.

10. A turbinated madreporite from Gothland: its disk bearing very much the appearance of the porpital madreporite.

11. A turbinated madreporite, apparently of the same species with the former, but of a more conical shape. Fossils resembling this and the preceding specimen are, I believe, frequently found in the island of Sheppy.

12. Is a cast of calcareous spar, formed in the vacuities of a turbinated madrepore: the remains of the animal having been removed by decomposition.

13 and 14. Two transverse polished sections of a large turbinated madreporite of the species at Fig. 8. The section, Fig. 14, made near to the pedicle, is seen to possess much fewer laminæ than the section Fig. 13, which was made where the coral had obtained its full thickness.

15. A delicately formed turbinated madreporite found in chalk.

16. A fossil of the same species in chalk. In this specimen the mode of attachment peculiar to these animals is shewn, the pedicle of the madreporite being adherent to the shell of an echinus.

17. Is the section of a piece of Blankenburg marble, in which is imbedded a turbinated madrepore of the species represented, Fig. 1, 2, and 3.

PLATE V.

FIG. 1. A madreporite resembling the fossil madrepore of Helwing, Fought, Volkmann, and others, which has been named *Madrepora Ananas*. At *a*, is shewn the mode in which, as in proliferous flowers, the newly-formed parts proceed from the centre of each existing disk. At *b*, is represented the mode of growth in the *Madrepora Stellaris*.

2. The madreporite from Gothland, known as *Madrepora Truncata*. At *c*, is shewn the proliferous mode in which the new joints arise from the surfaces of the already formed stars.

3. A polished transverse section of the *Lithostrotion* of Lhwydd, from Wales.

4. A fossil stellated madrepore, from Lincolnshire.

5. A madreporite, from Steeple Ashton.

6. The lithostrotion, or basaltiform madreporite, the transverse section of which is shewn, Fig. 3.

7. The spider-stone, or *Arachneolithus*, of Bruckman.

8. A stellated madreporite, from Ribieze, in Transylvania.

9. A madreporite, bearing somewhat of a honeycomb appearance, from Masbury, near Mendip.

PLATE VI.

FIG. 1. A polished slab of Kilkenny marble, which derives its figures from one species of the madreporites which have been called *Junci Lapidei.*

2. A species of madreporite of this kind from Derbyshire.

3. A polished slab of marble, deriving its figured appearances from a smaller species.

4. A madreporite, found in France, and frequently in Wiltshire, apparently the fossil described by Linnæus as *Madrepora Arachnoides.*

5. A fossil madrepore which has been hitherto named *Madrepora Pectinata.*

6. One of the stars of the madreporite, Fig 4, magnified.

7. A madreporite, the stars of which are very uncommonly formed.

8. A madreporite bearing much of the appearance of the *Madrepora Flexuosa,* from Bristol. This fossil is coloured by the red ferruginous impregnation which so generally tinges the fossils of this neighbourhood.

9. A madreporite of a very singular form and appearance, from near Ingleborough.

10. A slice of marble from Switzerland, beautifully figured by a fossil madrepore, which has been named *Madrepora Vermicularis.*

11. A madreporite which has been named *Madrepora Fascicularis,* and is remarkable for the frequency with which its transverse lamellæ occur.

12. Shews the general appearance of a polished section of chert, which is found frequently in some parts of Wiltshire. In this specimen a cast seems to have been formed, and the coral itself removed : the cast being afterwards impregnated with silex.

13. Is the appearance observable in other specimens of this chert, where the calcareous part of the madrepore has remained, having undergone the silicious impregnation.

PLATE VII.

Fig. 1. An elongated alcyonite from Touraine. In the superior part is seen the alcyonic texture; the calcareous matter having been removed by an acid, and the reticular silicified texture left.

2. A longitudinal section of the perpital madreporite; the inferior surface of which is represented, Fig. 4; and its superior, Fig. 5.

3. The under surface of an interesting compound madreporite of the porpital species from Dudley. An outline of part of its superior surface is represented, Fig. 7.

4. The inferior surface of a porpital compound madreporite. In the centre is the pedicle, which is surrounded by successive risings and depressions, concentrically arranged.

5. The superior surface of the porpital compound madreporite, the inferior surface of which is shewn at Fig. 4. Here crenulated openings are seen, surrounded by similar openings of a smaller size.

6. A ramose alcyonite, from Berkshire, bearing some resemblance of *Alcyonium Digitatum.*

7. The magnified appearance of part of the superior surface of the madreporite, represented Fig. 3, and which may be assumed as representing also the general alcyonic texture.

8. A magnified representation of the cruciform spines existing in the surface of the following fossil.

9. An alcyonite, somewhat resembling in its form *Alcyonium Cydonium* of Linnæus.

10. A compound madreporite of the turbinated species. Its general character resembles that of the fossils shewn at Fig. 2, 3, 4, and 5, excepting that by a protraction of the labours of the polypes several areæ have been formed, each extending beyond the last formed.

11. A stellated madreporite from Steeple Ashton. On its superior part is a sketch, shewing the manner and form in which madrepores of this species increased.

12. A ramose alcyonite, from Berkshire.

PLATE VIII.

Fig. 1. A piece of lime-stone composed of minute round bodies, the nature of which is unknown; but a magnified view of which is given, Fig. 12.

2. A branch of a fossil coral of the Isis genus, from Sicily.

3. A ramose milleporite, imbedded in a compact lime-stone, from Wiltshire; a magnified representation of a part of the surface of which is shewn, Fig. 11.

4. A joint of the trunk of the fossil Isis, a branch of which is represented, Fig. 2.

5. The inferior part of a fungiform alcyonite, or spongite, the plicæ of which are connected by anastamosings, similar to what takes place in the specimen, Plate XI. Fig. 3.

6. Part of a ramose madreporite, from Switzerland.

7. A joint of a fossil Isis, imbedded in its matrix.

8. A pebble, from the Hackney gravel-pits, bearing marks of organization in its surface. This fossil obtains illustration from the one at Fig. 10.

9. A ramose madreporite, imbedded in chalk, from France.

10. A pebble, from the gravel-pits, Hackney, on the surface of which are small roundish bodies connected by minute fibres.

11. A magnified representation of the surface of the milleporite, Fig. 3.

12. A magnified representation of some of the minute bodies forming a great part of the mass of the fossil, Fig. 1.

13. A magnified representation of a section of one of the round bodies, of which the following specimen is composed.

14. A silicious stone, composed of round bodies, the nature of which is at present unknown.

PLATE IX.

FIG. 1. A flint, from a gravel-pit. In this fossil are seen the ramifying filaments round the central opening; with the cortical part, under which these filaments seem to pass.

2. Is a silicious alcyonite, the surface of which is reticulated, except where part of its original external coat remains. The fossils depicted, Fig. 6, 9, and 10, appear to be of the same species.

3. A fig-like alcyonite, from Switzerland. In this fossil the pedicle, or organ of attachment, as well as its superior opening, is very evident.

4. An alcyonite, from Wiltshire, bearing somewhat of the form of *Alcyonium Ficus.*

5. A very perfect alcyonite, from the neighbourhood of Saumur, having four openings in its superior part, and the remains of several root-like processes.

6. A silicious alcyonite, beautifully marked, externally, with various risings and indentations.

7. A polished transverse section of a silicified alcyonium, resembling the supposed petrified nutmeg of Volkmann and Scheuchzer. In this specimen the regular arrangement of the muscular fibres, or tubuli, is seen.

8. A fig-formed alcyonite, of the same species with that which is imbedded in flint, Plate XI. Fig. 8.

9. A calcedonic alcyonite, possessing a reticulated surface.

10. A longitudinal section of the preceding fossil, shewing its internal structure.

11. The external superior part, with the opening of a ficoidal alcyonite.

12. A section of a ficoidal alcyonite, with fibres ramifying through its substance.

13. The polished transverse section of the ficoidal alcyonite, Fig. 11, shewing in the centre appearances like the receptacles for the pips of fruits.

14. A small calcareous spongite, or alcyonite, from Switzerland.

15. The appearance yielded in consequence of subjecting a similar fossil to the action of diluted muriatic acid.

PLATE X.

FIG. 1. A sketch of the inferior part of the fossil represented, Fig. 4. In this sketch is seen the arrangement of the circular and the radiating fibres, by the action of which a vacuum would be, probably, formed or destroyed, and the animal thereby fixed or liberated.

2. A magnified representation of the same fibres.

3. A magnified representation of the geniculated fibres on the convex surface.

4. The superior convex surface of the fossil.

5. An alcyonite resembling a cucumber in its form; and bearing some analogy with *Champignon de Mer* of Count Marsilli.

6. An alcyonite of a very singular form.

7. A small alcyonite, almost hemispherical, with a circular central opening.

8. A small hemispherical alcyonite, with a stellated central opening, and adherent to a flat alcyonite.

9. A small oblong alcyonite, with a circular opening.

10. A triquetral alcyonite, beset with minute circular pores. This and the three preceding fossils are from the canton of Basle, Switzerland.

11. An alcyonite investing a fossil nerite.

12. An alcyonite found in the chalk-pits of Wiltshire.

13. An alcyonite which much resembled the one, Plate XI. Fig. 7, deprived of its outer surface by the muriatic acid, and shewing the beautiful ramifications of its fibres, or tubuli.

14. A pebble, the figures on which are formed by the union of circular markings similar to those in Fig. 15.

15. A pebble frequently met with in gravel-pits; the markings on its surface having been the holes through which ramifications of an alcyonite have passed.

16. A pebble of the same kind with the preceding, longitudinally fractured, and thus shewing the alcyonite possessing a situation in its centre.

PLATE XI.

Fig. 1. An alcyonite formed of plicæ, connected by transverse processes thinly disposed.

2. An alcyonite, from Switzerland, of a singular form, having in its superior part a large central opening. *a* represents the magnified appearance of its structure, as obtained by polishing a part of its surface.

3. An alcyonite, the plicæ of which are more frequently connected by ramifying fibres, or tubuli, than those of Fig. 1, as is represented on the superior part of the fossil.

4. A flint, from Wycombe Heath, containing an alcyonite, which is of a purple hue, and is surrounded by its original covering, from which numerous tubuli may be seen passing into the more internal part.

5. Part of a funnel-formed alcyonite, from France. The labours of the polype may be traced on the edge at its superior part.

6. An alcyonite, in which the plicæ are very frequently connected by transverse processes, leaving quadrangular spaces.

7. A fungiform alcyonite, the structure of which much resembles that of Fig. 6.

8. A ficoid alcyonite, imbedded in a flint. The white matter which immediately surrounds the alcyonium appears to be its original cortical covering, as is observable in the fossil, Fig. 4. On the back part of this beautiful fossil is a purplish spot, where the pedicle passed out, produced by the transparent dark flint acquiring a tinge of red from the alcyonite: explaining the reason of the purple hue in the alcyonite, Fig. 4.

PLATE XII.

Fig. 1. A fossil body, found near Bath, the surface of which is nearly covered by stelliform markings, which seem to have been formed by a coralloid resembling that which is observed on the fossil, Fig. 2.

2. A coralloid fossil, from St. Peter's Mountain, near Maestricht, the nature of which has not been determined. This, and the other fossils from this mountain, Fig. 4, 6, 11, and 13, have been considered as casts; but this opinion appears to be incompatible with the numerous fibrillæ which exist in this specimen. *b*, a magnified representation of one of the stellated columns.

3. A silicious fossil from Essex, apparently of a similar nature with the fossils represented Plate VIII. Fig. 1, 8, and 10.

4. A coralloid fossil from St. Peter's Mountain, the original nature of which has not been determined.

5. A flint, containing an alcyonite from Southend, Essex.

6. A coralloid fossil from St. Peter's Mountain, the original nature of which has not been determined. *a*, the appearance yielded by one of its protuberances when viewed with a lens.

7. A silicious alcyonite from Sewardstone, Essex.

8. A calcedonic alcyonite from France.

9. An alcyonite of curious structure, in flint, from Essex; its substance, disposed in undulating plicæ, appeared to be capable of lengthening and contracting by the extension or the corrugation of its folds.

10. A silicious alcyonite, found in the neighbourhood of Islington.

11. A fossil from St. Peter's Mountain. In this fossil, the alcyonic structure, already noticed in the fossil, Plate X. Fig. 1, 2, 3, and 4, is very evident: at *d*, is seen the inner side of the superior concave surface, a part of which is shewn, slightly manifested at *f*; at *e*, is seen the flat inferior surface. From the appearances yielded by this fossil, it appears to be probable that the other fossils from St. Peter's Mountain, figured in this Plate, may have all partaken more of the nature of alcyonia than of corals.

12. A flint, supposed to owe its figure to an alcyonium.

13. A coralloid fossil from St. Peter's Mountain, the nature of which has not been yet determined: the marks on some parts of its surface, as shewn magnified at *c*, seeming to point out some resemblance to a microscopic tubipore, whilst the ruder and more numerous forms do not appear to be referrible to any known form of organization.

PLATE XIII.

FIG. 1.
2.
3.
4. Vertebræ of encrini, or trochitæ of different kinds.
5.
6.
7.

8. A series of vertebræ, in which is shewn the kind of motion of which these bodies are capable.

9. A distorted column, with the marks of attachment of vertebral processes.

10. The screw-stone, or pulley-stone, being the cast in the hollow of a series of vertebræ.

11.
12.
13.
14.
15.
16.
17. The articulating surfaces of different encrinal vertebræ.
18.
19.
20.
21.
22.
23.

24. The tortoise encrinite.

25.
26.
27. The articulating surfaces of different encrinal vertebræ.
28.

29. A series of vertebræ.

30. A single plate belonging to the tortoise encrinite.

31. The stag's-horn encrinite.

32. A series of oval vertebræ.

33. A vertebra with a curious articulating surface.

34. The straight encrinite.

35. A vertebræ of the straight encrinite.

36.
37. An asterial fossil from America; probably of the nature of the encrinus.

38. The apparent base of the stag's-horn encrinus.

39. Branches of the stag's-horn encrinite.

40. An oval vertebra.

41. A vertebra of the same animal, shewing the articulating surfaces crossing each other, and thus allowing a total change in the position of the different parts of the vertebral column.

42.
43.
44. Parts of different vertebral columns of encrini.
45.
46.

PLATE XIII. CONTINUED.

FIG. 47. Two trochitæ of the lily encrinite immersed in diluted muriatic acid, with the detached membrane, or rather cartilage.

48.
49.
50.
51.
52.
53. Various columnar star-stones, or series of different pentacrinal vertebræ.
54.
55.
56.
57.
58.

59. A quadrangular vertebra.

60.
61.
62.
63.
64. The articulating surfaces of different pentacrinal vertebræ.
65.
66.
67.
68.

69. An encrinal doliform tuberous vertebræ, with radiated articulating surfaces.

70. A series of vertebræ which are contracted in the middle of their length, and have their articulating surfaces oval, and disposed at right angles with each other on each vertebræ.

71. A smaller series, as though belonging to a branch or arm of the animal.

72. A still smaller series, apparently with its terminating tentaculum.

73. The base or organ of attachment, probably of this species.

74. A doliform vertebræ, supposed to belong to the succeeding species, from the similarity of their articulating surfaces, and of the substances of which they are formed.

75. The superior part of a bottle encrinite.

76. A similar specimen, to which is united its first vertebra.

77. The base or organ of attachment of a small species of encrinite.

78. An oblong vertebræ, agreeing so closely in its colour and articulating surfaces with the former fossil as to leave but little doubt of their belonging to the same species.

79. A clove-formed body, which is concluded to be the superior termination of a small encrinite, from being formed of ossiculæ united by suture, somewhat similar to what is seen in the bottle encrinite. From the exact agreement of their surfaces of articulation, its belonging to the same species with the two former fossils may be fairly inferred.

80.
81.
82. Fossil bodies, the nature of which is unknown.
83.

PLATE XIV.

FIG. 1. The lily encrinite, with part of its vertebral column attached to it. In this specimen is seen the extensive capacity for motion yielded by the peculiar form of the vertebræ in the superior part of the column; and by the fortunate removal of a portion of the fingers, a fair view is given of the natural arrangement of the tentacula.

2. The pentagonal base, composed of the ossa innominata, and forming with the scapulæ and clavicles, the pelvis, in which were contained, perhaps, the organs of digestion, &c.

3. The lily encrinite, detached from its vertebral column.

a the centre of its base, formed by five cuneiform ossiculæ, or *ossa innominata.*

a one of the *ossa innominata* detached.

b the ribs, or *articuli trapezoides;* forming, with the preceding bones, the pentagonal base.

b one of the ribs detached, shewing its internal surface.

c the clavicles.

c 1, the inferior surface.

c 2, the superior surface.

d the scapulæ.

d 1, the inferior surface.

d 2, the superior surface.

e the arms.

f the two first bones of the arms united.

g, h, i, k, l, m, the bones of the fingers gradually diminishing.

4. Part of the supposed base, or organ of attachment, of the lily encrinite.

5. The supposed base, or organ of attachment, of the cap encrinite.

PLATE XV.

Fig. 1. A polished slab of Yorkshire entrochal, or encrinal marble, shewing different sections of the vertebral column.

2. The pentagonal base of the cap encrinite of Derbyshire.

3. A specimen of encrinal marble, shewing the manner in which the fragments of the column are disposed in relief on the exterior surface, both in the Yorkshire and the Derbyshire marble.

4. A part of a large vertebral column belonging to the turban, or Shropshire, encrinite.

5. A part of the vertebral column, with the base, or organ of attachment, of the turban encrinite.

6. The screw-stone, or rather pulley-stone, being casts of the internal parts of the vertebral column of the cap encrinite.

7. A piece of marble from Shropshire, in which is discovered a part of the pentagonal base of the turban, or Shropshire, encrinite; the difference observable between which and that of the lily encrinite, Plate XIV. Fig. 2, and that of the cap encrinus, Plate XV. Fig. 2, shews plainly that this must have belonged to another species.

8. A small vertebral column of the turban encrinite.

9. The superior or body part of the cap encrinite of Derbyshire, and perhaps of Yorkshire.

PLATE XVI.

FIG. 1. Part of the vertebral column of the pear encrinite, of Bradford.

2. The superior vertebræ, gradually increasing in their diameter. The granulated appearance at the inferior part of this specimen proceeds from the attachment of some coralloid body, which has become petrified with the encrinus.

3. One of the vertebræ, last described, seen detached.

4. The clavicle, which is seen attached to the other parts, Fig. 6, 7, and 8. *a*, shewn separate.

5. Part of the vertebral column, which has acquired an additional covering of a purplish hue.

6. One of the most perfect specimens of this encrinite that I have seen. Here all the parts, particularly pointed out, Fig. 8, are again seen in their natural situation, and connected with the first joints of the fingers of the animal. The existence of the first bones of the fingers was ascertained by careful examination, after a farther clearing of the specimen, but not until the account of this specimen, page 211, had passed the press.

7. In this specimen the vertebræ are seen in connection with the clavicle and scapulæ.

8. A specimen * shewing the several parts in connection:

   a, the clavicle.
   b, the scapulæ.
   c, the bones of the arms.
   d, the last series of the bones of the arms, the superior surface having two concavities for the reception of the bones of the fingers.

9. Part of a vertebral encrinal column, with digitated processes passing out of each vertebra.

10. Part of a pentacrinal vertebral column, in the superior vertebræ of which are depressions for the insertions of the vertebral processes.

* A variety of formation seems to be observable between this specimen and the one, Fig. 7, in the line connecting the clavicle with the superior vertebræ: in the former a body is discoverable between the last vertebræ and each of the inferior convex points of the body, which I have considered as the clavicle. The admission of these bodies as ribs would render the analogy complete: and sufficient reason seems to exist for this admission; since the specimen, Fig. 7, is much more distinct in its markings than is either of the specimens, Fig. 6 or Fig. 8, both of which have a hacked surface, from the spathose crystallized substance.

PLATE XVI. CONTINUED.

FIG. 11. A body, apparently of ferruginous lime-stone, having much of the appearance of a pentacrinal vertebra. These bodies are worn by some of the Africans, strung together and forming necklaces.

12. The perpendicular section of a column, from Bradford, in which are seen the superadded coats, such as are also seen on the specimen, Fig. 5. In this specimen they are seen spreading out and giving an increase of thickness to the lower part of the column.

13. The perpendicular section of a beautiful agatine column, from Soissons, in which the superadded coats extending at the base of the column are very plainly perceived, forming a body well calculated to be the base or organ of attachment of this species of encrinite.

14. The section of the side of a column, from Bradford, in which the circumstances noticed in the preceding specimen are very evident.*

15. A section of pentacrinal marble, shewing longitudinal sections of the vertebral columns.

16. Vertebral columns, variously contorted, and connected together by lateral digital processes.

* Since the finishing of this Plate, I have procured a transverse section of the base of this species of encrinite, from Pfeffingen. It seems to yield similar appearances, except being three times the size, and of a purple colour, inclining to red, with those which a transverse section of the lower part of the French fossil, Fig. 13, might give.

PLATE XVII.

FIG. 1. Part of a nave encrinite, with a circular central opening, the carpal bones* of which much resemble those of the specimen, Fig. 10, taken from Dr. Capeller's plate.

2. Part of another encrinite, differing from the former in the size and form of its plates, and in having a stellated central opening.

3. The nave encrinite. This figure was taken from the original specimen in the British Museum. The opening at the superior part I believe to be the effect of injury.

4. Part of another encrinite, which seems to have very much resembled the preceding specimen.

5. Part of another encrinite, which appears to have much resembled the two former specimens.

6. A vertebral column of a pentacrinite, from Yorkshire.

7. A vertebral process, or appendix, of the Gloucestershire pentacrinite.

8. A part of the vertebral column of the Gloucestershire pentacrinite.

9. The superior extremities of the pentacrinite in an extended state.

10. A sketch of an encrinite, taken from Fig. 3, of a plate of Dr. Capeller.

11. A part of the vertebral column of a pentacrinite, supposed to be from Yorkshire.

12. The superior part of an encrinite, in the British Museum, from Ireland.

13. One of the ossiculæ of the arms of the pentacrinite, of its natural size, and slightly magnified.

14. One of the ossiculæ of the vertebral processes, of the natural size, and slightly magnified.

15. The superior part of the briaræan pentacrinite.
   a, the scapulæ.
   b, the clavicle.
   c, the first bone of the arm.
   d, the second bone of the arm.
   e, the commencement of two series of bones, attached to the superior part of the last bone of the arms, analagous with what has been seen to take place in most of the encrinites.

16. The vertebral column of the briaræan pentacrinite, with the articulated vertebral processes.

17. The termination of one of the vertebral articulated processes, slightly magnified.

* The propriety of the term carpal bones will appear when the forms of these bodies are attended to, and especially when it is observed that these bones, like the carpal, connect the fingers with the arm.

PLATE XVIII.

Fig. 1. The extended arms of the animal, with their various ramifications, on a slab of pyritical lime-stone, from Charmouth.

2. The arms of the animal collected together, as if for the purpose of confining its prey.

3. The vertebral articulated processes surrounding the pelvis, as if assisting in directing the prey to the mouth of the animal.

4. A fossil body, supposed to be species of oval encrinite.

PLATE XIX.

Fig. 1. A sketch of the part of the recent pentacrinus described by Mons. Guettard.

2. The superior part of a pentacrinite, found at Pyrton Passage, Gloucestershire. This sketch is copied from the fifty-second volume of the Philosophical Transactions.

3. Part of a funnel-formed alcyonium, filled with, and surrounded by, the green sand of Pewsey, in which it was found.*

* Not having been favoured with this specimen in time, I was unable to notice it in the body of the Work, or introduce it in the earlier Plates: and not having it, therefore, in my power to compare the Pewsey fossils with that represented in the Frontispiece, I was unable to determine whether the information which I had received respecting the locality of the latter fossil was correct or not. Comparison now enables me to state that the alcyonite in the Frontispiece appears to agree exactly in structure with the Pewsey alcyonites; but that the latter have evidently undergone a much more considerable chemical change than the former. The degree and kind of chemical change which the latter fossil has suffered seems, indeed, to authorize its being considered as a French fossil.

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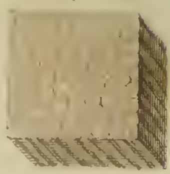

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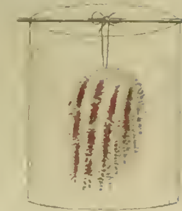

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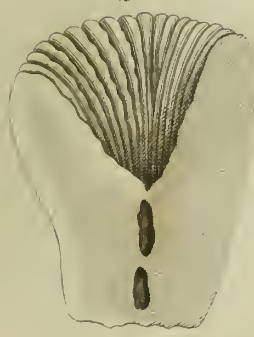

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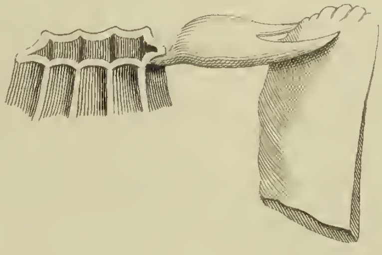

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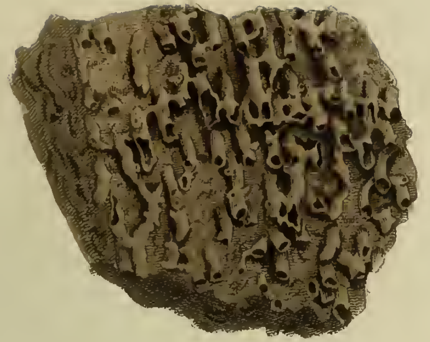

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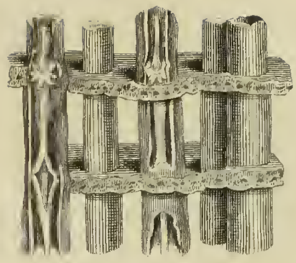

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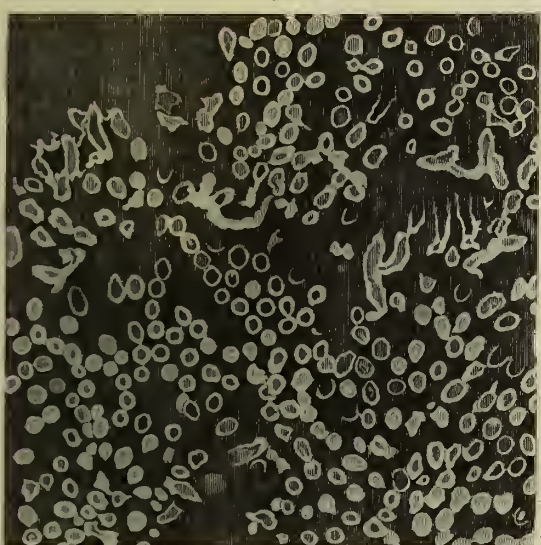

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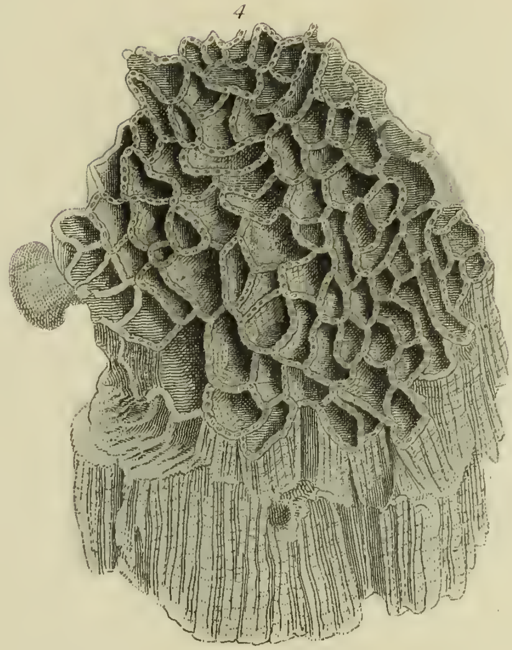

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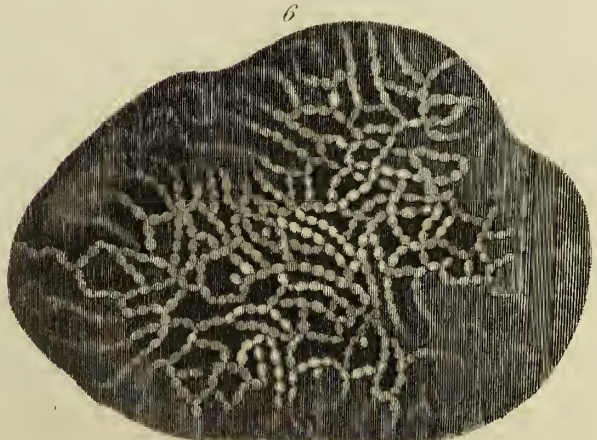

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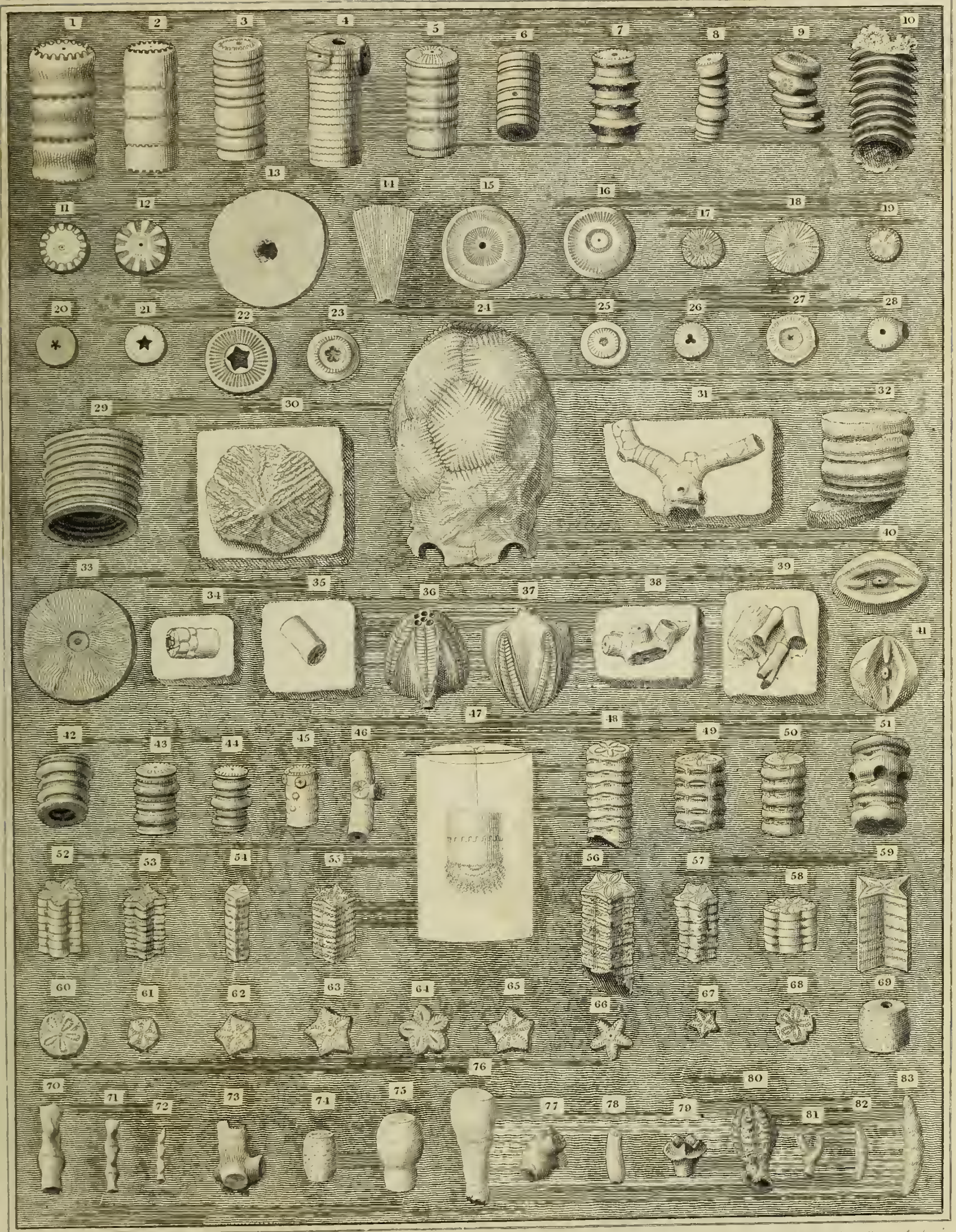

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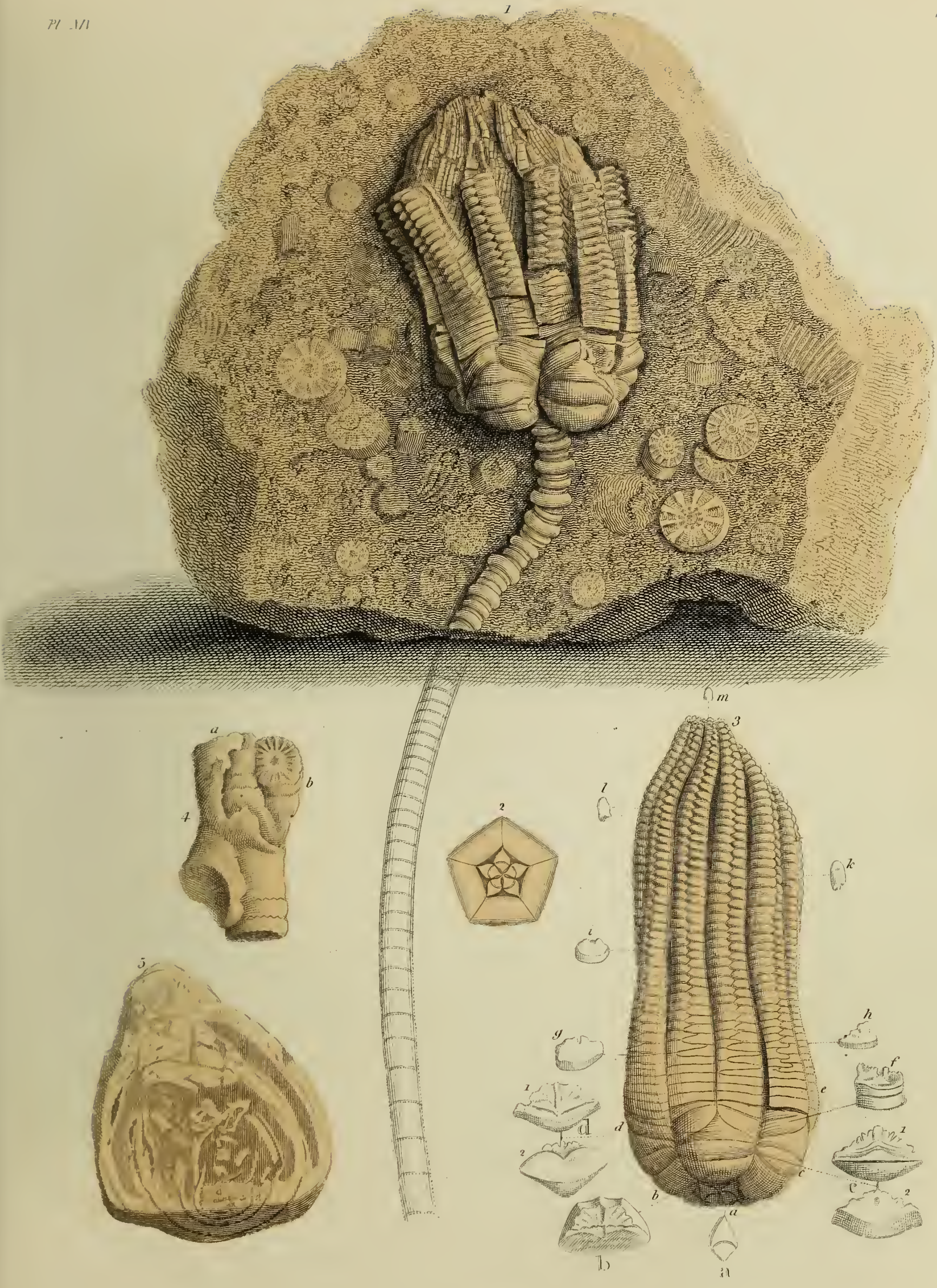

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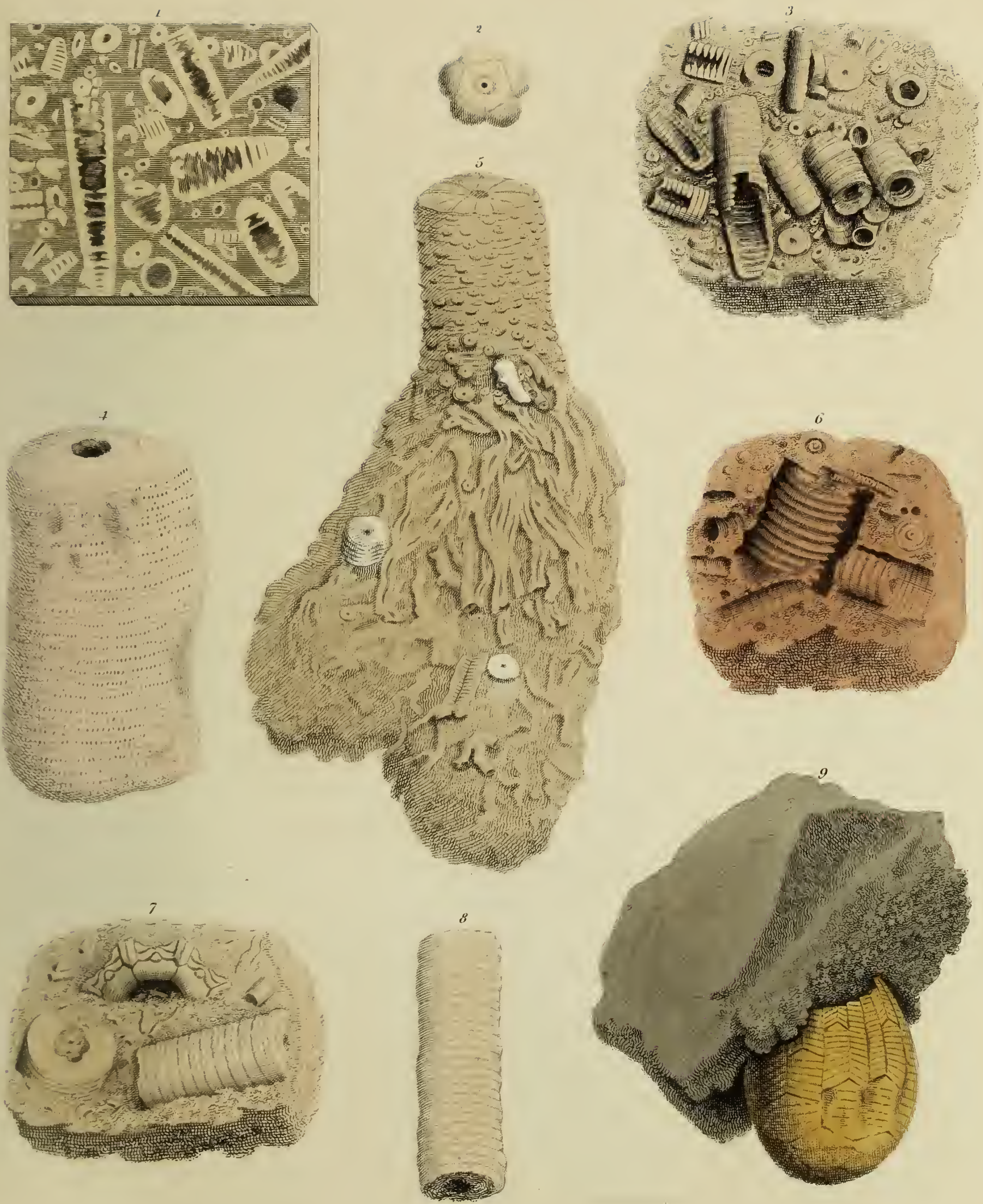

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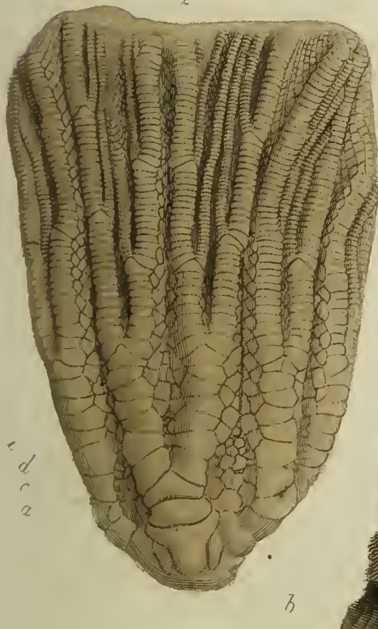

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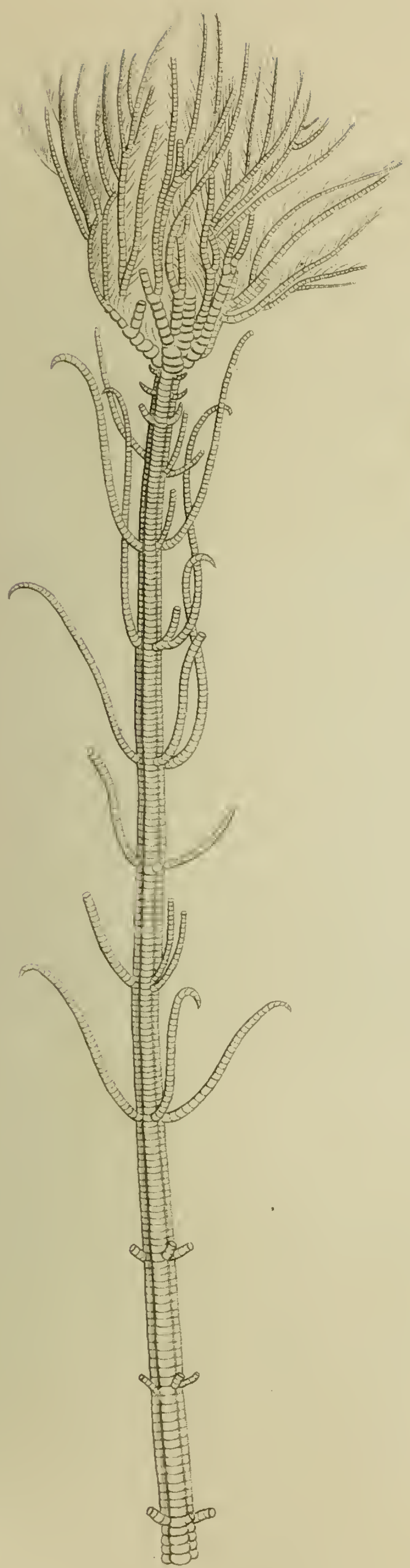

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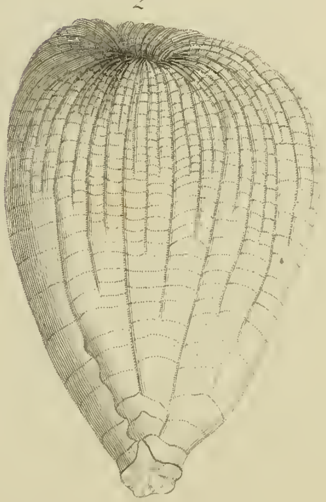

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